Editorial

Before the year is out...

The publication of this, the fourth and last Bulletin for 1999 (some would say of the century!) does not mean that we can just slacken off and idly await the Year 2000. On the contrary, legal metrology activity has never been so intense, as is proved by the extensive calendar of events we published in the July Bulletin and from the continuing stream of information that emanates from the Bureau (several hundred kg of mail per month!).

The BIML is moving into the fast lane and playing an ever-increasing role in coordinating events, bringing specialists together from around the world and providing information to Members and manufacturers, as well as advice and technical support on a daily basis.

The culmination of another year's activity is, of course, the CIML Meeting. This October our host will be Tunisia, which is especially appropriate since in addition to the regular CIML Meeting an extended Development Council meeting will be held: Tunisia took over the Chair of the Council a year ago. Things are set to move fast and a number of concrete proposals will be tabled.

In addition, a Round Table on Euro-Mediterranean Cooperation in Legal Metrology will take place in Tunis with the aim of assisting countries in the Mediterranean region to organize a cooperation in legal metrology which would be specific to the region and which would extend and deepen OIML work at regional level. In this era of lightning-fast information transfer via the Internet, computer technology and scientific progress, it may be that certain fundamental issues still have to be addressed before it is possible to enable specific regional issues to be resolved. Full reports of all three meetings will of course be published in the January 2000 issue of the Bulletin.

As we go to press, a number of key events are taking place at around the time of the CIML Meeting. The *Software in Measuring Instruments* Seminar will take place in Paris: the implications for legal metrology of changing technology are multiple, and we must keep abreast of new developments if we are to adequately adapt our activities to evolving measuring instruments. The APLMF and WELMEC Committee Meetings and the 13^{th} IAF Plenary Meeting are scheduled for September, followed in October by the 21^{st} *Conférence Générale des Poids et Mesures*, the ILAC '99 General Assembly and *Métrologie '99*. Three major events are already scheduled for the year 2000: *Metrology 2000* in Cuba (March 2000), the *International Conference on Metrology* in Jerusalem in May and of course the 11^{th} OIML International Conference of Legal Metrology, to be held in London in October 2000. Reports will be published on all these events in next year's volume.

So the end of 1999 promises to be as active, if not more so, than the first nine months of the year; the BIML is at cruising altitude and will continue to offer coordination, advice and assistance to its new and established Members worldwide, to seek new ways to initiate and respond to progress, develop the Organization's long term strategies and react to our ever-active environment with a commitment to advance. ■

Chris Pulham
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UNCERTAINTY

Uncertainty of measurement and error limits in legal metrology

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Abstract

Whenever standards are used for testing measuring instruments, they must be traceable to national or international standards. When the instruments have been calibrated, the measurement uncertainty is normally given on the certificate. If, however, the measuring instruments have been verified, the measurement uncertainty is not always quoted. This may be due to the maximum permissible errors (mpe) both on initial verification and in service. Generally, the requirements for calibration and testing are met by legal metrology, however some measures may have to be taken to ensure transparency and documentation.

Introduction

Due to the ever-increasing significance of quality management, a growing number of companies throughout the world have had their quality systems certified to the ISO 9000 series of standards. Both certification bodies as independent bodies for conformity assessment of products and calibration and testing laboratories need quality systems; in Europe these must meet the requirements found in the EN 45000 series of standards. These standards require measuring and test equipment to be traceable to national or international standards. As a rule, the quantities to be measured are traceable to SI units in an unbroken chain of comparison measurements carried out by competent bodies.

The concept of traceability not only requires an unbroken chain of comparison measurements, but also a statement and documentation of the measurement uncertainties. The statement of measurement uncertainties with reference to the standards used is an essential part of every calibration. Competent bodies will therefore normally accept calibrated instruments as test equipment within a quality management framework. The use of legally verified instruments for this purpose sometimes presents problems, since although the mpe's for the instruments are known, no measurement uncertainties are explicitly given. These problems are due to the different tasks and objectives of verification and calibration as well as to a lack of understanding between the two systems.

The authors hope to clearly identify the differences, but, at the same time, must point out that the same principles apply to the identical metrological aspects of both activities. No matter whether the metrological activities are performed in the regulatory or the non-regulatory areas, they must not deviate by more than is justified by the given objectives.

1 Objectives of verification

1.1 Historical development

The units of mass, volume and length are important since in commercial transactions their measurement determines the price. In the past, various interests as well as regional and historical differences led to differing units and systems. As cross-border trade increased in significance, pressure grew for harmonization; this resulted in the introduction of the SI system which not only became the legal basis for official dealings and commercial transactions, but also gained in importance in the non-regulatory field of industrial metrology. An efficient metrological infrastructure is the basis of all modern industrial societies and from this point of view, legal metrology was the pioneer of uniform measurement.

1.2 Legal requirements

The main objective of legal metrology is to protect citizens against the consequences of false measurements in official dealings and commercial transactions as well as in the labor, health and environment areas. As the interests of the parties concerned by measurements in these areas differ, the characteristics of the instruments used cannot be satisfactorily controlled by market forces. Legislation therefore lays down requirements not only for measuring instruments, but also for measuring and testing methods.

In Germany, these regulations are controlled by European Directives and by the Verification law. For individual categories of instruments, the regulations cover:

- the mpe's both on verification and in service;
- nominal conditions of use;
- susceptibility to external interference;
- electromagnetic compatibility (EMC);
- labeling;
- durability;
- tamper resistance; and
- reverification periods.

Everyone concerned with measurements should have instruments which give correct results within specified mpe's under the local environmental conditions. As the parties concerned by the measurements are not normally metrological experts, and do not have the capability of checking the results they are given, the State therefore takes responsibility for the validity of measurements within the framework of legal metrology.

1.3 Measures and procedures

In order to reach the objectives of legal metrology, both preventive and repressive measures are needed. Preventive measures are taken before the instruments are placed on the market or put into use and include pattern approval and verification. Market surveillance is an example of a repressive measure, and involves inspection of the instrument at the supplier's, owner's or user's premises. Here misuse of the instruments will be detected, and the offence may be punished by a fine.

The manufacturer has to file an application for pattern approval with the competent body. In Germany, this is the PTB; other European bodies as well as PTB are also responsible for European pattern approvals.

At least one sample of the instrument is examined to ensure compliance with the legal requirements. Approval tests and calibrations are carried out, and the results show whether the given requirements are met. It is particularly important to determine whether the mpe's at rated or foreseeable *in situ* operating conditions are likely to be met. The sample instrument is also subjected to quality tests which should guarantee its reliability in use.

For reasons of efficiency, verification usually only requires a single measurement (observation) to be carried out. It is therefore important that the spread or dispersion of measured values is determined during the type approval tests. This determination of so-called *a-priori* characteristic values forms the justification for the evaluation of the uncertainty of measurement on the subsequent verifications.

Upon successful type approval testing, a manufacturer has in principle proven his technical competence to manufacture an instrument that meets the legal requirements.

As pattern approval is a test of the pattern, it is followed by verification testing on each instrument. This ensures that every single instrument conforms with the pattern. After the initial verification validity period has expired, reverification will be done by a verification body. When a single owner (particularly an energy or water utility) has a large number of instruments, reverifications may be carried out on samples. The reverification requirements, in particular the mpe's, are the same as those at initial verification, which means that the measurement uncertainties have to be handled in the same way.

European harmonization allows the manufacturer to carry out conformity assessment on new instruments as an alternative to verification by a verification body. This leads to the need to harmonize the measuring and testing methods, including determination of the measurement uncertainties and accounting for them in conformity assessments. Some relevant terms and definitions are given below.

2 Metrological terms and definitions

2.1 Uncertainty of measurement

According to the VIM (3.9) [1] measurement uncertainty is a "parameter, associated with the results of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand".

Measurement uncertainty is usually made up of many components, some of which may be determined from the statistical distribution of the results of series of measurements and which can be characterized by experimental standard deviations. The other components, which can also be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information.

Contributions to the measurement uncertainty are:

- the standards used;
- the measuring and test equipment used;
- the measuring methods;
- the environmental conditions;
- susceptibility to interference;
- the state of the object to be measured or calibrated; and
- the person performing the measurement or calibration.

The *Guide to the Expression of Uncertainty in Measurement (GUM)* [2] and document EA-4/02 [3] give detailed information on the determination of measurement uncertainties and a summary of the contributions (cf. Section 3).

2.2 Calibration

The VIM (6.11) [1] defines a calibration as "a set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards". This means that the calibration shows how the measured value or the nominal value indicated by an instrument relates to the true or conventional true values of the measurand. It is assumed that the conventional true value is realized by a reference standard traceable to national or international standards.

Not only the measurement uncertainty but also the environmental conditions during the calibration are significant. The calibration is often carried out in a place with well-known environmental conditions, which leads to low measurement uncertainties. When the calibrated instrument is used in a different environment the measurement uncertainty determined by the calibration laboratory will often be exceeded if the instrument is susceptible to its environment. There can also be a problem if instrument performance deteriorates after prolonged use. The user of the calibrated instrument must therefore consider any environmental or secular stability problems.

2.3 Testing

According to ISO 8402 [4] testing implies the statement that conformity for each of the characteristics was achieved. EN 45001 [5], however, states that a test is a technical process in the sense of an examination to determine the characteristic values of a product, procedure or service.

The quantitative requirements stipulated for instruments refer to the measurement errors, the values of which must not exceed the mpe's. The measurement error itself is in practice recognized to be the result of a measurement minus a conventional true value [1]. Calibration of the instrument over the given measuring range at given environmental conditions is the prerequisite for an assessment of conformity with regard to error limit requirements being met.

Whereas a measurement result implies an uncertainty of measurement, a complete testing result implies an uncertainty of testing. This leads to an *uncertainty of decision* with regard to conformity assessment. A distinction must be drawn between quantitative and qualitative tests, and as a rule a measurement uncertainty can be assigned in a quantitative test. An assessment of any qualitative characteristics of the object under test, e.g. of a measuring instrument, also requires uncertainty statements. This means that the measurement uncertainty determined during the calibration is only a contribution to the total uncertainty.

2.4 Verification

The verification regulations lay down the tests and marking of an instrument. The initial elements of verification are:

- a qualitative test, which is effectively an inspection; and
- a quantitative test, which is almost the same as a calibration.

These two elements of verification are tests in the sense of the EN 45000 series of standards. Once they have been performed, the matter of certification can be considered.

Here the test results are evaluated to ensure that the legal requirements are being met. During this evaluation it is particularly important to establish that the calibration results demonstrate that the mpe requirements are satisfied.

Assuming that the evaluation leads to the instrument being accepted, a verification mark or label must be fixed to it, and, where relevant, tamper evident seals. A verification or evaluation certificate may be issued.

3 Calculation of the measurement uncertainty

Basically, the determination of the measurement uncertainty refers to the calibration inherent in conformity verification (cf. 2.4). Therefore the procedures given in the GUM [2] and in EA-4/02 [3] are applicable:

(a) Defining the objective

As a rule, the basic objective in legal metrology is the determination of the expanded measurement uncertainty (k = 2), for the difference between the measuring instrument under test and the standard.

(b) Drawing up a model function

The model function expresses in mathematical terms the dependence of the measurand (output quantity) Y on the input quantities X_i according to the following equation:

$$Y = f(X_1, X_2, ..., X_N) \qquad (1)$$

In most cases it will be a group of analytical expressions which include corrections and correction factors for systematic effects [3].

Where a direct comparison is being made between the indications shown by the instrument under test and the standard, the basic equation may be simple:

$$Y = X_1 - X_2 \qquad (2)$$

Example 1: Testing of a filling station fuel dispenser by means of a standard measuring container

Measurand Y:	Deviation of the indicated fuel volume from that actually delivered
Input quantities X_K related to the instrument to be verified:	Fuel dispenser indication, measuring system temperature, liquid temperature, etc.
Input quantities X_l related to the standard used:	Level indication, deviation of container from horizontal, fuel environment temperatures, foam layer thickness, etc.
Other input quantities X_m:	Loss of fuel during the measuring process due to evaporation or adhesion, incorrect operation, etc.

(c) Type A evaluation of uncertainty contributions

This is done by statistical analysis of a series of observations, normally by calculation of the arithmetic mean value and its experimental standard deviation. The estimates x_i of the input quantities X_i have to be determined, and the standard uncertainties u_i are the standard deviations mentioned above [2], [3].

(d) Type B evaluation of standard uncertainty of input quantities

Method A normally assumes that the measurement values are normally distributed and that the standard uncertainty is indicated in terms of the empirical standard deviation of the mean. When using method B however, the probability distribution to be applied must be considered in more detail.

If the distribution is unknown, and no data from which an uncertainty could be deduced are available, values have to be based on scientific experience. If maximum or minimum tolerances can be assumed (even by approximation), the standard uncertainty has to be calculated on the basis of a rectangular distribution [2], [3]. This is also applicable to measurements with working standards in legal metrology.

Example 2: Measurement with a 50 L standard measurement container

The uncertainty contribution for a 50 L standard measurement container where only the nominal volume and mpe's are given has to be determined by applying the rectangular probability distribution.

mpe $(\Delta V_N / V_N)_{max}$:	0.1 %
Resulting standard uncertainty $u(V_N)$:	$\Delta V_N / \sqrt{3} \approx 29 \text{ cm}^3$

(e) Calculation of the sensitivity coefficients

The sensitive coefficient can be found from the model function by:

- partial differentiation of the model function by the individual input quantities at all relevant values of their estimates:

$$c_i \approx (\delta Y / \delta X_i) |_{x_i} \qquad (3)$$

and/or:

- (computerized) numerical variation of the input quantities according to their quantification and taking into account the change in the output.

Experimental determination of the relationship between output and input quantities is also possible.

(f) Compilation of an uncertainty budget

Sources of uncertainty must be listed in tabular form, together with their respective input estimates x_i, standard uncertainties $u_k(x_i)$, and contributions $u_i(y)$ to the uncertainty associated with the output estimate y.

(g) Calculation of the output estimate and of the associated standard uncertainty

The standard uncertainty of the output estimate is determined by adding the contributions $u_i(y)$ in quadrature. This gives the square of the standard uncertainty $u(y)$ of the measurand. It is essential to consider the possibility that some of the contributions may be correlated, and so not truly independent [2], [3].

(h) Statement of the complete measurement result

The complete measurement result includes the output estimate y and the expanded uncertainty of measurement $U(y)$. This identifies the range within which the output will be found with a probability of approximately $P = 95$ %.

When the measurement uncertainty of a verification is to be determined, it should be remembered that normally only individual measurements are made. This means that evaluation method A may only be applied if relevant *a-priori* data, e.g. for the standard deviation of a certain type of instrument, exist. Logically, the standard uncertainty of the individual measurement, i.e. the standard deviation of a series of observations, will then be included in the output rather than the standard uncertainty of the mean.

As a rule, *a-priori* data are determined in type approval tests. Moreover, for many instrument categories, e.g. fuel dispensers, comprehensive experience or statistical values are available.

Formal application of the above scheme is not sufficient for the determination of the measurement uncertainties. The chief prerequisite for a realistic result is a complete model which is close to reality. Critical and honest evaluation of the estimated values of the input quantities can only be based on sound experience.

4 The significance of measurement uncertainty in practice

4.1 Calibration

A calibration gives a systematic measurement error together with a statement of the measurement uncertainty. This not only relates to the correct value derived from the reference standard, but also takes account of the environment during calibration. The temperature is of particular importance here but humidity, air pressure and electromagnetic fields may also make a considerable contribution to the measurement uncertainty.

As a rule, instruments to be used as reference standards will be calibrated under controlled environmental conditions. If these newly calibrated instruments are then used in the same environmental conditions, it can be assumed that they will have the same measurement uncertainty. When an instrument is being calibrated against such standards, its uncertainty u_s enters into the total uncertainty of measurement u_{meas} as an (uncorrelated) contribution:

$$u^2_{meas} = u^2_s + \Sigma u^2_i \qquad (4)$$

where u_i are contributions to the measurement uncertainty related to the calibration procedure and to the nature of the object under test.

If, on the other hand, a calibrated standard is used in different environmental conditions and after prolonged use, higher uncertainties must normally be assigned.

Calibration therefore makes a statement about an instrument's behavior only at the moment it is carried out. The user must assess on the basis of his technical knowledge whether the calibrated instrument is suitable or not. If a calibrated instrument is to be used to evaluate the uncertainties of measurements and tests under other environmental conditions, particularly strenuous requirements will have to be met. Calibration certificates do not normally contain any statements about the long-term behavior of the object.

4.2 Testing

While the term "measurement uncertainty" is clearly defined and used [1], the term "uncertainty of testing", which means uncertainty as to the properties of the object under test, is not yet harmonized. Proposals for harmonization have been put forward by the European Cooperation for Accreditation of Laboratories (EA) [7].

No matter whether an application is covered by regulations or not, a quantitative test on a measuring instrument should state whether the values determined lie within the mpe. For this reason, a calibration (including a measurement uncertainty statement) is required.

Figure 1 shows possible interrelations between the intrinsic error of a measuring instrument [1], the mpe and the uncertainty of measurement.

In cases a, b and c, the instrument is within the mpe. In case d, non-compliance with the requirements is proven and in cases e and f no unequivocal statement of conformity can be made. Here, the parties concerned must agree on acceptance or rejection of the instrument. This kind of assessment is, *inter alia*, required for the testing through measurement of manufactured items and instruments by ISO 14253 [8].

4.3 Verification

4.3.1 Maximum permissible errors on verification and in service

Verification is a special method of testing covered by regulations laid down by legislation. In OIML Recommendations and in many economies with developed legal metrology systems, two kinds of error limits are defined:

- the mpe on verification; and
- the mpe in service, which in most cases is twice the mpe on verification.

The mpe on verification equals an "mpe on testing" which only applies at the time of the verification. The mpe in service is the one that is legally relevant for the user of the instrument.

Figure 2 explains this approach to the effect that during the time of use of a measuring instrument within the period of the validity of the verification, the indicated measured value will drift to some extent and the uncertainty of measurement will in most cases clearly rise due to the realistic operation conditions and external interference. In particular the following influences must be taken into consideration:

- measurement uncertainty from the metrological test during verification;
- normal operating conditions;
- external interference during normal operation; and
- long-term behavior, drifting, aging and durability.

The mpe on verification may be exceeded here, however requirements regarding the mpe in service must in general be met. As a result, verification implies a high probability that under normal conditions of use the measuring instrument will furnish measurement results within the given mpe's in service during the entire validity period of the verification.

In practice, measuring instruments are considered to be in compliance with the legal regulations:

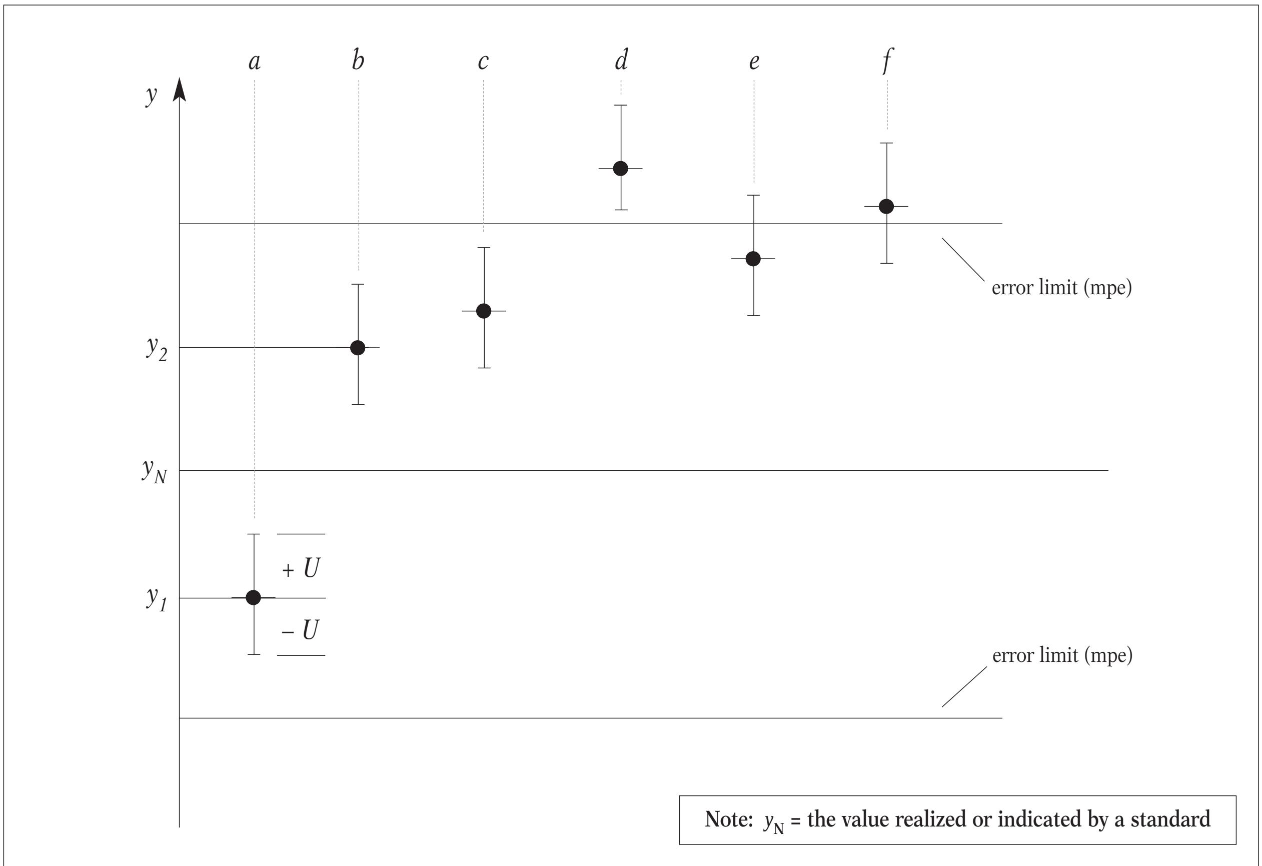

Fig. 1 Influence of the (expanded) uncertainty of measurement of various measurement results y_j on conformity assessment in testing

- if the indicated value is smaller than or equal to the mpe on verification when the test is performed by a verification body under unified test conditions; and
- if the uncertainty of measurement at the 95 % probability level is small compared with the prescribed error limit.

In legal metrology at present, the uncertainty of measurement is usually considered to be small enough if the so-called "one-third uncertainty budget" is not exceeded:

$$U(\mathrm{k} = 2) \leq 1/3 \cdot MPEV \quad (5)$$

where *MPEV* is the mpe on verification.

The criteria for the assessment of compliance are illustrated in Fig. 3. Compliance with the requirements of the verification regulations is given in cases *a, b, c* and *d*. Cases *e* and *f* will result in rejection, although all the values including the uncertainty of measurement lie within the tolerances fixed by the mpe's in service.

As regards the mpe on verification, the described approach above is called the "shared risk concept": provided that inequation (5) applies, the (systematic) error of measurement determined is not extended by the uncertainty of measurement when one checks whether it exceeds the error limits on verification. In this way there is an approximately shared risk that a test result lying on the extreme edge of the tolerance band may be inside or outside the permissible limit.

Therefore, the mpe on verification of a newly verified measuring instrument will in the worst case be exceeded by 33 %. However, as the legally prescribed mpe's in service apply for the user of the measuring instrument, there is no shared risk in the sense that no measured value - even if the measurement uncertainty is taken into account - will be outside this tolerance band.

So far, the mpe's on verification can be seen as a supporting guide for the conformity assessment of mpe's in service being met in order to take the above-mentioned influences into consideration.

To a far-reaching extent the influence of the operating conditions at the place of use, the effect of interferences and the long-term behavior must be ascertained during pattern testing by the type approval body; here, experience gained with the same category of measuring instruments will be included in the assessment.

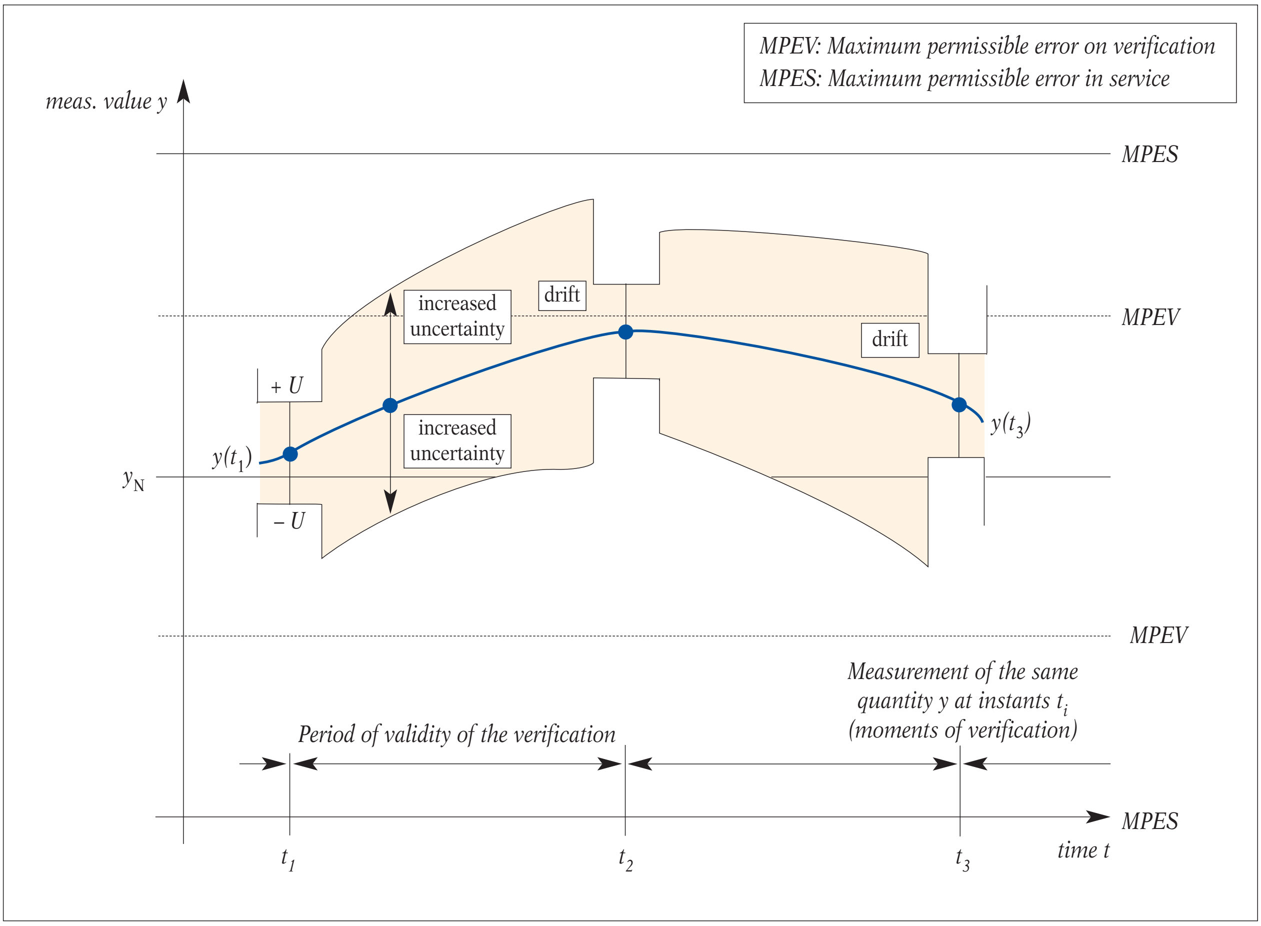

Fig. 2 Consideration of long-term drift and external influences by definition of two kinds of error limits: mpe on verification and in service

4.3.2 Standards and testing methods

When carrying out the tests required in legal metrology, the uncertainty of measurement predominantly depends on the reference standards. To ensure that the test is traceable to national standards, the reference standards of the conformity verification bodies are calibrated by the relevant national institute of metrology (in Germany, the PTB). The systematic errors and the measurement uncertainties associated with these reference standards are given on test or calibration certificates.

The verification bodies derive the traceability of their working standards from these reference standards. In most countries with a highly developed legal metrology system, the working standards can deviate from the conventional true value indicated or realized by the reference standard used by no more than one third of the mpe on verification. Here the expanded measurement uncertainty (k = 2) of the measured quantity should be taken into consideration. As the comparison of the standards is performed under laboratory conditions, the measurement uncertainty may be minimized. As a rule, systematic components will predominate the error budget. If the working standard meets the "one-third uncertainty requirement", its systematic error and the measurement uncertainty will not be considered during verification in order to make the metrological tests cost-efficient. When the "one-third uncertainty requirement" (cf. 4.3.1) does not apply, systematic errors have to be individually accounted for.

ISO/IEC DIS 17025 [6], which is a more recent draft standard, also recommends the 1:3 ratio between the measurement error or measurement uncertainty, and the prescribed tolerance. This is a practice which has been applied in legal metrology for many years. The testing periods for standards are also laid down by law.

In verification, metrological testing methods are applied which were optimized and harmonized by the responsible bodies based on the experience of verifying millions of measuring instruments. In Germany, there are about 25 million instrument verifications per year. As long as the prescribed conditions at the place of testing are met, additional external influences and subjective factors will not cause measurement uncertainties to exceed the error limits of the working standards. As a rule these uncertainty contributions are therefore neglected. However, this practice is only acceptable if:

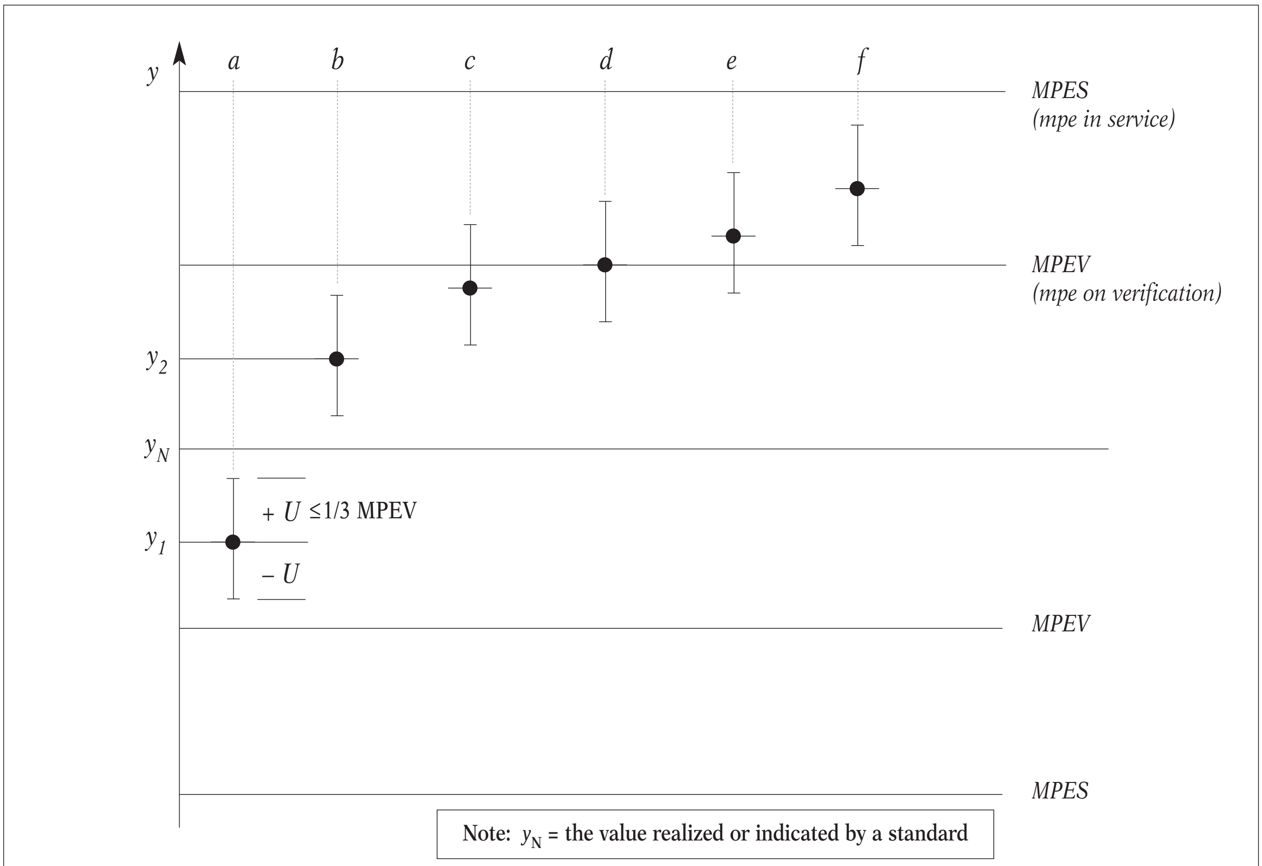

Fig. 3 Influence of the uncertainty of measurement U (k = 2) of various measurement results y_i on conformity assessment in verification

- the uncertainty attached to the working standard is clearly within the "one-third uncertainty budget";
- the additional contribution of uncertainties does not contain serious systematic error components; and
- all contributions other than the measurement uncertainty of the standard used total less than 20 % of the mpe on verification.

Example 3 illustrates these relations:

Example 3: Verification of a fuel dispenser

mpe on verification (MPEV)	0.500 %
"One-third uncertainty budget" (0.33 MPEV)	0.166 %
Relative expanded measurement uncertainty (k = 2) of the standard measuring container (58 cm^3; cf. Example 2)	0.116 %
Contribution of measurement uncertainties (k = 2) arising from procedure and external influences (20 % of 0.500 %)	0.100 %
Total measurement uncertainty (added in quadrature)	0.153 %

The measurement uncertainty contribution from the procedure and the external influences is unusually large, amounting to 20 % of the mpe on verification. Despite this, due to addition in quadrature, the total uncertainty in the above example is not much greater than that of the standard, and the "one-third budget" will be met.

The above strategy may also be based on the normally rather high error limits in legal metrology, the "one-third uncertainty budget" being on the safe side as far as the measurement uncertainties are concerned.

However, the effect of ignoring the measurement uncertainties arising from the test procedure and from external influences must be considered critically. If the specified ambient conditions are exceeded in the test, the respective contribution of these uncertainties can increase to more than 20 % of the mpe on verification.

If all the requirements are met, the mpe on verification (MPEV) will in the worst case be exceeded by 33 % (case *d* in Fig. 3).

For reasons of consumer protection and efficient manufacturing of measuring instruments, it is important for competent authorities and manufacturers to have a quantitative estimate of the consequences of the measurement uncertainty in conformity verification on the quality of the instruments to be placed on the market. The following two questions are of particular importance:

- what is the proportion of newly verified measuring instruments to be expected which actually exceeds the mpe on verification?
- what is the proportion of newly verified measuring instruments to be expected which actually exceeds 1.33 times the mpe on verification?

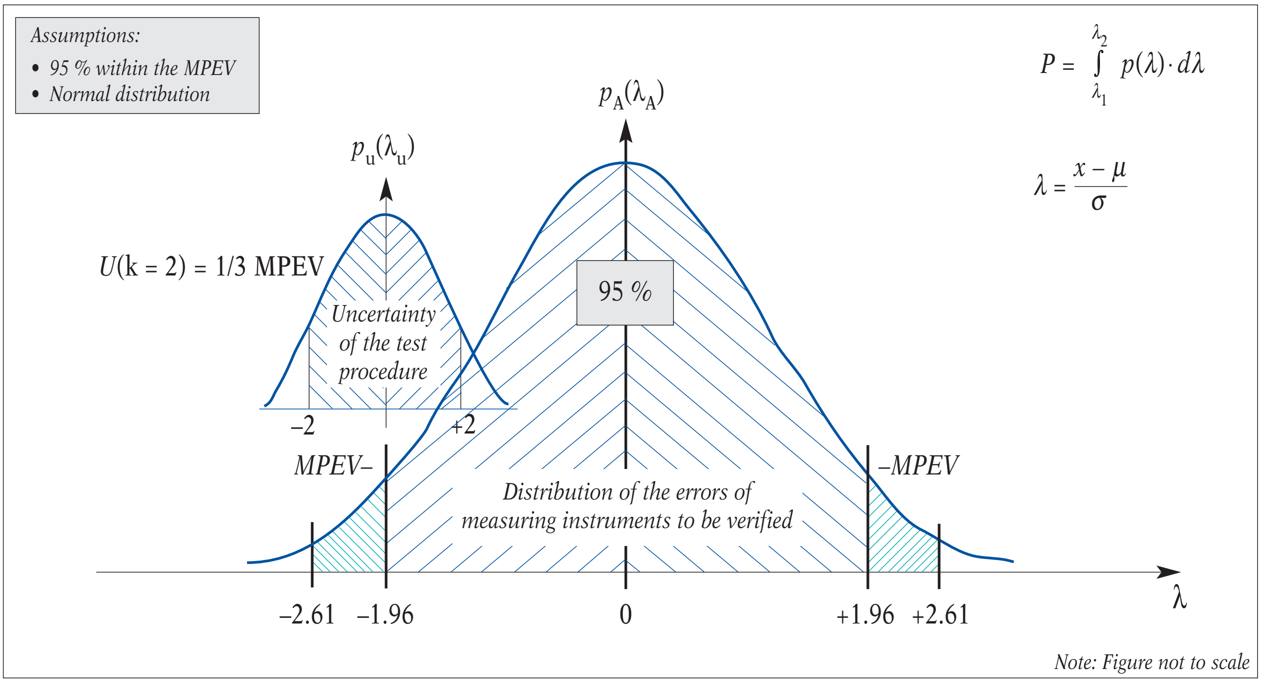

Fig. 4 Consideration of uncertainties of measurement in conformity decisions

The answers to these questions are illustrated by Example 4.

Example 4: Consequences of the measurement uncertainty in conformity assessment on a batch of instruments

The calculation will be based on the typical case of a unit-tested batch of instruments where the intrinsic measurement errors due to manufacturing variation more or less follow a normal distribution. This implies that 5 % of the instruments will in fact lie outside the error limits. In addition, it is assumed that the spread of values resulting from the uncertainties in the metrological test are normally distributed, and that the measurement uncertainty amounts to the maximum permissible value of U (k = 2) = 0.33 MPEV.

Figure 4 illustrates these conditions. If a measurement error is based on the (lower) error limit, combination of both distributions will result in the following:

(a) The expected proportion of "faulty" instruments which are assessed as indicating correctly will be less than 2 %;

(b) The probability that the mpe on verification will be exceeded by a factor of more than 1.33 is practically zero. (cf. Fig. 4).

The significance of statement (3) made in Example 4 has to be emphasized.

To reach the mpe in service an extra (reserve) tolerance is therefore available. It equals 66 % of the mpe on verification at minimum. Thus the effects of temporal drift and additional external influences on the measurement result may safely be compensated (cf. 4.3.1). This means even after prolonged use and with varying external influences, the risk for the user that the mpe in service is exceeded is practically zero.

The fact that, even in the worst case, the value of the mpe on verification is not exceeded by a factor of more than 1.33 facilitates conversion into other systems. An example is the situation where it is required that the sum of the measurement error and of the expanded measurement uncertainty must lie within given assessment limits.

5 Conclusions

5.1 Present situation

Due to the legal regulations to which verification is subjected, the user of a verified instrument may assume that during the validity period the instrument will indicate values within the mpe's in service. This is the case even if the measurement uncertainties are taken into consideration so that there is no shared risk. If the environmental conditions during use are the same as those prevailing during verification, the values can be expected to be even better than the mpe's on verification (probability 95 %). But in the worst case, for a small proportion of the instruments, they may be 1.33 times the mpe on verification. This value is significant for the user of an instrument which is outside the regulatory sphere, but who still has to prove traceability to national standards.

Verification comprises calibration and certification. These should comply with the international technical regulations, e.g. with ISO/IEC DIS 17025 [6]. For calculation or estimation of measurement uncertainties, the GUM [2] and EA-4/02 [3] are equally applicable. However, calibration is only part of the verification, and adaptations are required to take this into account. Some generalizations are also required for consumer protection reasons.

5.2 Further development

It should be remembered that the GUM guidelines concerning measurement uncertainties in legal metrology are incomplete. New instructions for calibration and testing including measurement uncertainty calculations have to be established and a future concept should include at least the following measures:

- integration in the uncertainty budget ("one-third uncertainty budget", presently being confined to the working standard) due to the testing procedure and the instrument under test during verification;
- definition of the mpe in service as the limit which must not be exceeded in the metrological evaluation for consumer protection reasons. The deviation extended by the measurement uncertainty (k = 2) should be less than the mpe.
- if someone is going to use a verified measuring instrument as a standard in accordance with the ISO 9000 series, they should be informed of the relationships between:
    - measurement uncertainty;
    - the mpe on verification; and
    - the mpe in service.

In the past, government bodies were not required to prove such transparency. Due to the increasing transfer of regulatory tasks to private institutions and manufacturers within the framework of international harmonization, government authorities are also required to meet uniform regulations. ■

References

[1] *International Vocabulary of Basic and General Terms in Metrology*, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1993

[2] *Guide to the Expression of Uncertainty in Measurement*, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, Corrected and reprinted, 1995

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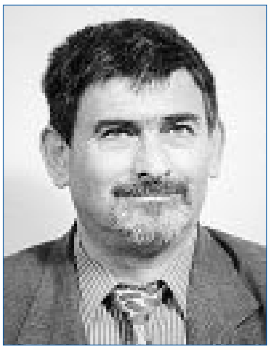
Note from the BIML: A “Secondary Guide” to the expression of measurement uncertainty in legal metrology is being developed as an application of the GUM. A working document prepared by Gérard Lagauterie, Sous-Direction de la Métrologie, France, was distributed at the TC 3 meeting held in June 1999, a report of which is published in this Bulletin. Several attending persons, including Dr. Sommer, participated in discussions. The continuation of this work project has been allocated to the recently established TC 3/SC 5 *Conformity Assessment*, under the joint responsibility of the USA and the BIML. ■

STATISTICAL CHECKING



Mathematical control of the randomness of gambling devices

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Abstract

In some cases, mathematical statistical checking is the only way to adequately test gambling devices and the two most frequently used methods (i.e. the 3σ method and the χ^2 method) are discussed in this paper. Because the χ^2 method cannot be used in its classical form for testing lottery-type games, it was necessary to develop it so that it could also be applicable for this purpose. For both roulette and lottery-type games, the second and the third members in the series of the distribution function of the variable χ^2 are also determined in order to form an improved test method.

1 Introduction

In Hungary, as in some other European countries, the technical control of gambling devices is legally the task of the national metrological institute; mathematical statistical checking of the random (and therefore fair) operation of such devices also falls under the institute's responsibility. In some cases huge prizes are drawn by simple devices made of wood, whose structure cannot be tested by classical metrological means; mathematical checking of these devices is therefore the only possible official control method. Considering the fact that in this field written standards are not available, it is vital that the authority's decision as to whether a device is accepted or rejected be well-founded and indisputable.

This paper shows the mathematical bases of the two most important statistical methods mentioned above, which are most frequently used for type approval and verification. These mathematical methods can be used not only for gambling devices but also for other purposes, for example to check a hypothesis about a probability distribution or to check a computer's random number generator.

In some cases during the author's research it was necessary to further expand on existing methods, or even to elaborate new ones; these can be found in paragraphs 4, 5 and 6 below.

2 The 3σ test

The method is given for the case of roulette wheels but can, of course, be used in other fields too.

Roulette wheels used in Hungary have numbers 1 to 36 plus a single zero, so the number of possible spin outcomes equals 37, usually designated by *v*. One of the steps in testing the randomness is to check the hypothesis that the probability of spinning any number out of the 37 is the same:

$$p_j = \frac{1}{v} \quad (j = 0, 1, ..., 36).$$

When a roulette wheel is submitted for testing the client must provide a list of the last *N* spins, in sequential order. Such lists used to be written by hand, though nowadays they are made electronically using a data collector connected to the corresponding roulette table electronic display device. The i^{th} number on the list, i.e. one of the numbers 0 to 36, is designated by x_i ($i = 1, 2, ..., N$) and *N* is prescribed not to be less than $100v = 3700$ in order to ensure that all 37 numbers occur at least 100 times *on average*. The prescribed number $N = 100v$ can really be judged as being a compromise: sometimes clients consider it as being too big, but to ascertain the smaller deviations of a roulette wheel more data would be necessary.

On the basis of the list the frequencies k_j of the occurrence of the numbers j ($j = 0, 1, ..., 36$) are determined, where the frequency k_j shows how many times the number j occurred among the values x_i.

In the case of a roulette wheel operating regularly, i.e. randomly, every frequency k_j is a random variable following a Bernoulli distribution with an expectation:

$$\mu_j \equiv \langle k_j \rangle = Np_j = \frac{N}{\nu}$$

and with a theoretical standard deviation:

$$\sigma_j \equiv +\sqrt{\langle (k_j - \mu_j)^2 \rangle} = +\sqrt{Np_j(1-p_j)} = +\sqrt{\frac{N}{\nu}\left(1-\frac{1}{\nu}\right)}$$

So for every frequency k_j the condition:

$$\boxed{\mu_j - 3\sigma_j \le k_j \le \mu_j + 3\sigma_j}$$

has to be fulfilled with a high probability, the value of which is approximately 99.73 %. The factor 3 that precedes σ_j gave this test its name, which - according to the author's experience - can be judged as being optimal. The choice of a smaller factor would result in a higher risk of the *first order error,* when roulette wheels operating correctly would be rejected more often, since the data would be outside the interval more often. The choice of a higher factor would increase the risk of the *second order error*, when unacceptable roulette wheels would be accepted.

The above method is used by most roulette wheel manufacturers to check their product, with the modification that the frequencies of odd/even, red/black, etc. numbers are also examined. However, this test only controls the "uniformity" of the frequencies of the numbers spun, and says nothing about their randomness. A roulette wheel spinning consecutively increasing numbers (e.g. 15, 16, 17 or 35, 36, 0, etc.) would pass the above test properly; every frequency k_j would fall *in the center* of the prescribed interval, despite the fact that the "decisions" of the given roulette wheel would be *extremely predictable* and not random at all. The operation of a roulette wheel is deemed to be random if no regularity can be found in adjacent numbers. *Hence the randomness of the sequence of the numbers spun must also be checked.*

For this purpose one can employ several methods, for instance the correlation method. According to the author's experience one of the simplest, most efficient and most demonstrative methods is to take the difference between the numbers in sequence:

$$y_{i,1} \equiv x_{i+1} - x_i \quad (i = 1, 2, ..., N-1).$$

Since the previous differences can be negative, the next non-negative quantities $z_{i,1}$ are formed:

$$z_{i,1} \equiv \begin{cases} y_{i,1} & \text{if } y_{i,1} \ge 0 \\ y_{i,1} + \nu & \text{if } y_{i,1} < 0 \end{cases} \qquad (1)$$

The so-called *modulated differences* $z_{i,1}$ can have values between 0 and 36 too, and if the roulette wheel operates regularly the distribution of the frequencies k_j, calculated on the basis of the values $z_{i,1}$, must also obviously be approximately uniform, similarly to the frequencies k_j calculated from the original data in the list. Hence for the frequencies k_j calculated on the basis of the values $z_{i,1}$, the foregoing 3σ test is also performed, taking $(N-1)$ instead of N. A wheel spinning numbers incrementally would fail this test; the frequency k_1 belonging to the "channel" number 1 (i.e. belonging to $z_{i,1} = 1$) would be much bigger than the upper limit of the given interval and all other frequencies k_j would equal zero.

Considering that the 3σ test is used not only for roulette wheels, but to control computer programs drawing prizes, for example, the above test is performed not only for the differences $z_{i,1}$, calculated from the adjacent numbers on the original list, but for the modulated differences $z_{i,k}$, that are calculated from the k^{th} neighbors. The $z_{i,k}$ modulated differences are defined as follows:

$$y_{i,k} \equiv x_{i+k} - x_i; \text{ here } k = 1, 2, 3, ... \text{ and } i = 1, 2, ..., N-k.$$

$$z_{i,k} \equiv \begin{cases} y_{i,k} & \text{if } y_{i,k} \ge 0 \\ y_{i,k} + \nu & \text{if } y_{i,k} < 0 \end{cases}$$

Using this method the gross errors, the short periodicity of the random generator of the computer or of the drawing program can be found out.

Performing the test for the 4^{th} neighbors too, there are $5 \times 37 = 185$ frequencies on the data page of a roulette wheel. Since "only" P = 0.9973 probability belongs to 3σ, among these data sometimes (but regularly) some frequencies do not fulfil the 3σ condition, however the roulette wheel under control operates well. In these cases the decision to accept or reject it is partly subjective; the quantity, the place (the column and the line in the page) and the magnitude of the "overstepping" are examined.

The great advantage of the 3σ test is that it can generally be used for most gambling games such as slot machines or for lottery-type games, and in the case of rejection it gives an indication as to the possible reason for the deviation. However the 3σ test does have a disadvantage: unambiguous "mechanical" decisions cannot be made in the case of overstepping, i.e. when one or more frequencies are outside the given interval. Partly for this reason and also to render the decision better founded, as an addition to the 3σ method sometimes the χ^2 test is also performed on the same data. In other cases only the χ^2 method is used.

3 The χ^2 test for roulette-type games

Games are considered as being of the roulette-type where, at least in principle, it is possible to witness the same phenomenon of successive incremental spins described above. Roulette wheels (and most slot machines) belong to this category for instance. In the case of roulette wheels, repetitions of numbers must occur regularly. From the point of view of mathematics, roulette-type games differ from lottery-type games to a significant degree: in the latter, the numbers drawn during one game are always different. Such games are, for instance, the 90/5 lottery, where five different numbers are always drawn out of 90, the 45/6 lottery, the 80/20 keno, and all types of bingo games.

The χ^2 test is based on the very important statistical theorem described below, which is widely used for checking hypotheses on probability distributions.

Let the random events $A_1, A_2, \ldots, A_j, \ldots, A_v$ mutually exclude each other and let them constitute a complete system of events. In this case for the probabilities $p_1, p_2, \ldots, p_j, \ldots, p_v$ of the events the condition:

$$p_1 + p_2 + \ldots + p_j + \ldots + p_v = 1$$

is true, i.e. during one experiment one (and only one) event out of v different possible events will occur. Let k_j designate the frequency of the event A_j occurring out of N experiments where, of course, $k_j = 0, 1, 2, \ldots, N$ and

$$\sum_{j=1}^{v} k_j = N$$

(it is important to note that the greatest possible value of each frequency k_j equals N, which is the total of all the numbers spun in the case of roulette wheels). The set of frequencies k_j follows a v-variable Bernoulli distribution:

$$P(k_1, k_2, \ldots, k_v) = \frac{N!}{k_1!\, k_2! \ldots, k_v!}\; p_1^{k_1} p_2^{k_2} \ldots p_v^{k_v}$$

and according to the theorem the distribution limit of the next random variable constituted from the frequencies k_j:

$$\chi_R^2 \equiv \sum_{j=1}^{v} \frac{(k_j - Np_j)^2}{Np_j} \qquad (2)$$

is a χ^2 distribution with $r = v - 1$ degrees of freedom, if $N \to \infty$. Using the formulae, if $N \to \infty$:

$$Pr(\chi_R^2 < x) \equiv \phi_{\chi_R^2}(x) = F_{v-1}(x) \qquad (3)$$

Here the index R of the variable χ^2 indicates the roulette-type game, and $F_{v-1}(x)$ designates the distribution function of the χ^2 distribution with $r = v - 1$ degrees of freedom. Developed over the course of time, the fact that a random variable and a probability distribution are traditionally designated by the same symbol χ^2 may be inconvenient, though the random variable χ_R^2 appearing in (2) above is of an χ^2 distribution only in the case when $N \to \infty$, and not in general.

As a reminder, the density function f_r, the distribution function F_r and the first two moments of the χ^2 distribution with r degrees of freedom are given, which have the greatest importance during practical use:

$$f_r(x) = \frac{1}{\Gamma\left(\frac{r}{2}\right)} \frac{1}{x} \left(\frac{x}{2}\right)^{\frac{r}{2}} e^{-\frac{x}{2}}$$

$$F_r(x) \equiv \int_0^x f_r(y)dy = \frac{1}{\Gamma\left(\frac{r}{2}\right)} \sum_{k=0}^{\infty} \frac{(-1)^k}{\left(k + \frac{r}{2}\right)k!} \left(\frac{x}{2}\right)^{k+\frac{r}{2}}$$

Here the Γ function is traditionally defined as:

$$\Gamma(x) = \int_0^\infty y^{x-1} e^{-y} dy$$

If x is an integer, then $\Gamma(x) = (x - 1)!$ The expectation of the χ^2 distribution with r degrees of freedom

$\mu \equiv \int_0^\infty x f_r(x)dx = r$, and its variance

$$\sigma^2 \equiv \int_0^\infty (x - \mu)^2 f_r(x)dx = 2r$$

For practical purposes it may also be important that the χ^2 distribution with r degrees of freedom can be well approximated by a normal distribution, whose expectation equals r and whose standard deviation equals $\sqrt{2r}$, if the degree of freedom r is big enough.

When performing the mathematical test on roulette wheels, for instance, the χ^2 method can be used as follows:

a) on the basis of the data in the list sent in by the client, the frequencies k_j are determined;

b) supposing that the $p_j = \frac{1}{v} = \frac{1}{37}$ condition is true, i.e. the roulette wheel under control operates regularly, each number is spun with the same probability, on the basis of formula (2), the value of the variable χ_R^2 is calculated;

c) for an appropriate probability P of acceptance (the value of which usually equals 0.9973 belonging to the 3σ), supposing that the number N of the data is big enough for formula (3) to be used, the critical value χ^2_{crit} is determined from the condition

$$P = \phi_{\chi^2_R}(x = \chi^2_{crit});$$

d) the values of the variable χ^2_R and the critical values χ^2_{crit} are also determined for the modulated differences $z_{i,k}$, if necessary.

From a mathematical point of view the roulette wheel can be accepted if the condition(s):

$$\boxed{\chi^2_R \le \chi^2_{crit}}$$

are fulfilled for the base data and for the modulated differences $z_{i,k}$ as well.

The great benefit of the χ^2 test is that it always gives the possibility to make an unambiguous decision, but its disadvantage is that it does not give any information about the possible reasons in the case of rejection.

4 Improvement of the χ^2 test for roulette-type games

The χ^2 test is used not only for checking roulette wheels, where the condition $N >> 1$, necessary for the use of formula (3), is fulfilled in practice, but its application would sometimes be useful when the number N of the experiments is not big enough or if it cannot be ascertained whether it is big enough. In these cases the decision of the authority based on mathematical tests would not be well enough founded and sufficiently indisputable. For this reason the distribution function $\phi_{\chi^2_R}(x)$ of the random variable

$$\chi^2_R \equiv \sum_{j=1}^{v} \frac{(k_j - Np_j)^2}{Np_j}$$

defined by formula (2), was examined in detail, and it was established that the relation $\phi_{\chi^2_R}(x) = F_{v-1}(x)$, that is true in the case of $N \rightarrow \infty$, is the first member, independent of N, of a series according to the powers of

$$\frac{1}{\sqrt{N}}$$

In order to make the distribution function more exact the second and the third members of the series were determined too. Since the second member, which is proportional to

$$\frac{1}{\sqrt{N}}$$

equals zero, the distribution function of the variable χ^2_R is:

$$\phi_{\chi^2_R}(x) = F_{v-1}(x) + \frac{2x}{v-1} f_{v-1}(x) \left[-A - B + \frac{x(A+2B) - \frac{Bx^2}{v+3}}{v+1} \right] + O\left(\frac{1}{N^{3/2}}\right)$$

where: $$A = \frac{v^2 + 2v - 2 - \sum_{j=1}^{v} \frac{1}{p_j}}{8N}$$

$$B = \frac{5\sum_{j=1}^{v} \frac{1}{p_j} - 3v^2 - 6v + 4}{24N}$$

and $f_{v-1}(x)$ and $F_{v-1}(x)$ are the density function and distribution function of the χ^2 distribution with $v - 1$ degrees of freedom, respectively.

The previous formulae contain the expression $\sum_{j=1}^{v} \frac{1}{p_j}$ which is small for a fixed value of v when all the probabilities p_j are almost equal, i.e. when the probability distribution of the events A_j is approximately uniform. This fact confirms the rule, as can be seen from the literature, that prescribes almost uniform distribution for the successful use of the first approximation, i.e. of the classical χ^2 test. According to that rule it is also necessary for every event A_j to occur at least 10 times. In the case of slot machines neither the first nor the second conditions can be fulfilled: the probability distribution of the different winning combinations occurring differs from the uniform distribution to a significant degree, and it cannot be ensured either during all the tests that the very infrequent "jackpot" will occur 10 times at least.

Hence considering the second and the third member in the series makes it possible to *prove* the correctness of using the first approximation or to make well-founded decisions even in the cases when the conditions necessary for the use of the first approximation cannot be fulfilled.

5 The χ^2 test for lottery-type games

If out of the numbers 1, 2, ..., j, ..., v during one draw n different numbers are drawn, for instance in the case of a 90/5 lottery $n = 5$ different numbers out of $v = 90$ and every number has the same probability of being drawn, then the probability of being drawn is obviously:

$p_j = p = \frac{n}{v}$ for all the v numbers.

If the draw is repeated N times, the frequencies k_j of the numbers j occurring among the numbers drawn can be determined from the data of the N drawings, similarly to roulette-type games. However, here for the frequencies k_j obviously the following conditions have to be fulfilled:

$$k_j = 0, 1, 2, ..., N \text{ and } \sum_{j=1}^{v} k_j = Nn.$$

Every frequency k_j follows the same Bernoulli distribution:

$$P(k_j) = \binom{N}{k_j} p_j^{k_j} (1 - p_j)^{N-k_j} = \binom{N}{k_j} p^{k_j} (1 - p)^{N-k_j}$$

with the expectation $\langle k_j \rangle \equiv \mu = Np$ and with the variance $\langle (k_j - \mu)^2 \rangle \equiv \sigma^2 = Np(1 - p)$.

It is quite logical on the basis of the foregoing to define the next random variable:

$$\chi_L^2 = \sum_{j=1}^{v} \frac{(k_j - Np)^2}{Np} \quad (4)$$

similarly to the case of roulette, and to hope that its distribution extends to a known distribution limit, for example to the evident χ^2 distribution, if $N \to \infty$. The distribution limit of this variable χ_L^2 (where L refers to the lottery) cannot be derived on the basis of the theorem shown in paragraph 3 above, since the conditions of use of that theorem are not fulfilled here; the set of frequencies k_j *does not follow a multivariable Bernoulli distribution*, however, every k_j in itself is of (simple) Bernoulli distribution. Even in principle it is impossible that every number occurs Nn times (as in the case of roulette), though the number of all the drawn numbers equals Nn. Every number j can occur N times at most. However, it is a lucky circumstance, that for $n = 1$ the variable χ_L^2 is the same as the variable χ_R^2, if the relation $p_j = 1/v$ is true. Therefore their distributions (and consequently their distribution limits) must be the same as well. This fact makes it easier to check the correctness of the relations obtained.

In order to "guess" the distribution limit required, let us determine the expectation of the variable χ_L^2.

$$\langle \chi_L^2 \rangle = \sum_{j=1}^{v} \frac{\langle (k_j - Np)^2 \rangle}{Np} =$$

$$= \sum_{j=1}^{v} \frac{\sigma^2}{Np} = \frac{v\sigma^2}{Np} = \frac{vNp(1 - p)}{Np} = v(1 - p) = v - n$$

Is the distribution limit that is sought after a χ^2 distribution with a degree of freedom $v - n$? Let us also determine the variance of χ_L^2. As a result of calculations that are more complicated than the foregoing,

$$\sigma_{\chi_L^2}^2 \equiv \left\langle \left(\chi_L^2 - \langle \chi_L^2 \rangle \right)^2 \right\rangle = 2 \frac{(v - n)^2}{v - 1} \left(1 - \frac{1}{N}\right)$$ can be given.

Because for $N \to \infty$ $\sigma_{\chi_L^2}^2 \to 2 \frac{(v - n)^2}{v - 1}$, it can be guessed that the distribution of the next variable Y

$$Y \equiv \frac{v - 1}{v - n} \chi_L^2 \equiv \frac{v - 1}{v} \sum_{j=1}^{v} \frac{(k_j - Np)^2}{Np(1 - p)} \quad (5)$$

goes to a χ^2 distribution with $v - 1$ degrees of freedom, since the expectation of the variable Y equals $\mu_Y = v - 1$ and its variance is:

$$\sigma_Y^2 = 2(v - 1)\left(1 - \frac{1}{N}\right) \to 2(v - 1)$$

Indeed, using the method of the characteristic functions it was proved that for the case of $N \to \infty$

$$\phi_Y = F_{v-1}(x) \quad (6)$$

The theorem can also be proved for the more general case, when the probabilities p_j belonging to the event, that the number j is occurring among the n numbers drawn, are not equal, but this proof is quite complex and is not necessary for our purposes.

Applying the above theorem the χ^2 test can also be used for lottery-type games, if the number N of the draw results, in the list available for the tests, is great enough.

6 Improvement of the χ^2 test for lottery-type games

Sometimes huge prizes are drawn in lotteries, which is why it is of special importance that the mathematical test methods of the randomness of the games must be indisputable. For this purpose the second and third members of the distribution function of the variable Y, given by formula (5), were defined as well. Hence the distribution function:

$$\phi_Y(x) = F_{v-1}(x) -$$

$$- \frac{x}{6N} \frac{f_{v-1}(x)}{v + 1} \left[3(v + 1 - x) + \varepsilon \left(v + 1 - 2x + \frac{x^2}{v + 3} \right) \right] +$$

$$+ O\left(\frac{1}{N^{3/2}} \right)$$

where:

$$\varepsilon \equiv \frac{(v-1)(v-2n)^2}{n(v-2)(v-n)}$$

It can be seen that n appears only in the formula of ε. The values of ε for $n = 1$ and for $n = v - 1$ are the same, therefore the distributions of Y must also be the same in these two cases. This fact is not unexpected at all, since the task of choosing one number out of v is equivalent to the task of choosing $v - 1$ different numbers out of v. At the same time, for $n = 1$ the distribution function of the variable Y is equal to the distribution function of the variable χ^2_R, if

$$p_j = \frac{1}{v}\text{, i.e. } \sum_{j=1}^{v} \frac{1}{p_j} = \sum_{j=1}^{v} v = v^2 \qquad (7)$$

is substituted therein, as it must be, since fulfilling condition (7) - i.e. in the case of uniformly distributed probabilities p_j - the variable χ^2_R forms a special case of the variable Y.

Because in the case of lottery-type games the order in which the numbers are drawn is not of any significance, here it is not reasonable to perform the χ^2 test for the modulated differences $z_{i,k}$ too. The sequence of the results of lottery drawings has not been recorded in statistics for several decades; the numbers drawn are reported only in increasing order.

7 Conclusions

One means (and in the given cases the only possible means) of testing gambling devices is the mathematical statistical checking of draw or spin results. This paper shows the 3σ and the χ^2 tests, which are most frequently used. The advantages and disadvantages of both methods are given, on the basis of which it can be established that the two methods are complementary to each other, therefore if possible both should be used. If a χ^2 test results in a rejection, it is useful to perform the 3σ test too in order to ascertain the reasons for this rejection.

The conventional χ^2 method cannot be used for testing lottery-type games, which is why the author has put forward additional calculations that allow the χ^2 test to be used for this purpose as well.

Considering that the χ^2 test is used not "only" for checking scientific hypotheses but also for establishing an official decision about acceptance or rejection, the improvement to the χ^2 test was made for both kinds of games, i.e. for roulette and lottery-type games. This gives the possibility to *prove* the correctness of use of the first approximation or to use the χ^2 test in cases when the conditions for using the first approximation cannot be fulfilled, for instance when the number N of the experiments is not big enough, or when the probability distribution of the events A_j is not uniform. ■

HISTORY OF ITALIAN METROLOGY

Legal metrology in the city of Naples during the Aragonese domination (1442–1503)

SILVANA IOVIENO, W&M Officer, Ufficio Provinciale Metrico e del Saggio di Metalli Preziosi di Napoli, Italy

The Aragonese were faced with a complex situation in the field of weights and measures in so far as the ancient traditional measures used in trade were very disparate due to the presence of a number of "independent" measurement standards, to the lack of any effective control on the part of the authorities and even, in some cases, to outright abuse by these authorities in implementing checking procedures.

To remedy this situation and hence ensure uniformity of measurements, King Ferdinand I of Aragon issued a legislative act in April 1480. He even had a monument carved to ensure not only that word got round about this act but also that it was actually put into practice, and additionally sent details of the act to the appointed head magistracy. Even though the monument became damaged over time, it was nevertheless preserved up until the last century in the Castelcapuano courtyard in Naples, which was the office of the Royal Court of the Weights and Measures Mint. The marble stump bore Aragonese insignia and the Latin inscription:

FERDINANDUS.REX.INUTILITAT
EM.REI.P.HAS.MENSURAS.PER.MAGIST
ROS.RATIONALES.FIERI.MANDAVIT

The monument was engraved with the linear and capacity measures in force at that time. Some samples were also conserved by the church, in line with an ancient law of Giustiniano that was, by then, becoming a tradition since in a Christian society the church was considered as being the best place to confer absolute and indisputable values to measures that were derived from the human body, such as the palm of a hand or the foot.

Ferdinand's legislative act is not conserved in published collections, but was recorded thanks to the transcription made by the humanist Melchiorre Delfico in 1787 [5].

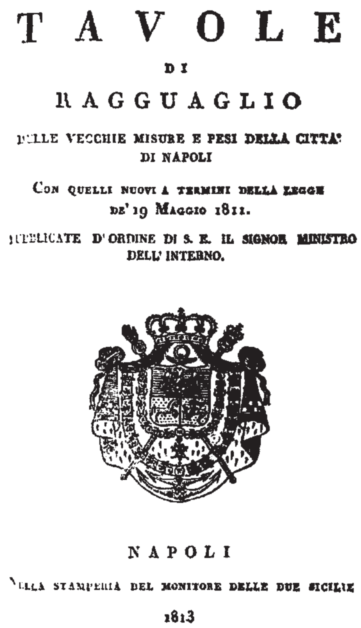
Ferdinand's edict was of note because it led to order being restored in the field of weights and measures that remained untouched for the next four centuries.

Unfortunately, there is no historical record of how the weights and measures that he imposed as being legally binding under his reign were actually determined.

At the beginning of the 19th century a Committee of Learners was charged by Gioacchino Murat (King of Naples from 1808 to 1815) to compare the Aragonese measures with the Parisian metre, to inquire into the origins of the system of measures being used and to establish if a scientific principle existed that had inspired the inventors of the Neapolitan system of weights and measures [2].

Castelcapuano, which was the site of the Royal Court of the Weights and Measures Mint

King Ferdinand I of Aragon



TAVOLE
DI
RAGGUAGLIO
DELLE VECCHIE MISURE E PESI DELLA CITTA'
DI NAPOLI
CON QUELLI NUOVI A TERMINI DELLA LEGGE
DE' 19 MAGGIO 1811.
PUBBLICATE D'ORDINE DI S. E. IL SIGNOR MINISTRO
DELL' INTERNO.

NAPOLI
NELLA STAMPERIA DEL MONITORE DELLE DUE SICILIE
1813

(10)

CORRISPONDENZA

Delle attuali misure e pesi di Napoli con quelli del sistema decimale francese.

	MISURE e pesi di Napoli.	MISURE lineari franc	MISURE di capacità fra.	PESI françesi.
		Metro.	Litri.	Grammi.
	Misura lineare, palmo . . .	0,26367		
Misure di capacità	Caraffa di vino, detta di vendita a minuto	. . . . . .	0,660419	
	Caraffa di vino detta di botte.	. . . . . .	0,727027	
	Misura da olio, detta quarto	. . . . . .	0,619534	
	Misura per gli aridi, detta tomolo . . .	. . . . . .	55,234	
Peso	Libbra	. . . . .	. . . .	320,759

Approvato, GIOACCHINO NAPOLEONE.
Per certificato conforme,
Il Ministro Segretario di Stato,
firmato, PIGNATELLI.

Measure conversion table from the "Monitore del Regno delle due Sicilie" (Official journal of the Kingdom of Naples) published in 1813 under King Gioacchino Murat

This comparison showed that the Parisian meter was in fact bigger that the Aragonese "four palm" measure by 1/200 m, but the sample examined was not in a good state and was marred by the intensive use that had been made of it over the four centuries during which it constituted the sole legal basis.

The committee found no reference as to the origins of the system of measurement used in Naples, despite having searched right through the Royal Archives.

Moreover, it is curious to note that since the Aragonese era the mile (the unit of the customary survey measure used in Naples) was defined to be 1/60 of a degree of the earth's meridian and the palm (the unit of linear measure used in Naples) as 1/7 000 of the mile; it can therefore be affirmed that since the time of Alfonso I of Aragon, linear measurement was strictly related to the length of the earth's meridian.

The fact that in 1811 the Committee found such a small and "wonderful" [5] difference between the Aragonese measure and the French metre led the scientific establishment in the last century to consider that the palm originated as an aliquot part of the earth's meridian almost four centuries before the invention of the metre. It would have been a major achievement for the illustrious (and unfortunately ignored) Committee of Naples at the Aragonese court to have proved this!

View of the Castel Nuovo (also called "Maschio Angioino"), site of the Aragon Government

It can be noted from the analysis of the instructions King Ferdinand gave to his treasurers that an "ad hoc" structure for regular control of every weight, measure and instrument that the sellers used to weigh and measure was created for the first time in the Reign of Naples.

During Ferdinand's reign the law also established a hierarchy of primary standards, to render it easier to compare these with the standards used by instruments in trade.

It provided for the creation of a register containing details of anyone using instruments to weigh and measure for trade purposes (in the Middle-Age Italian language: "quinterni lucidi et clari"); this register enabled the Central Administration to examine the behavior of the appointed head magistracy for instrument control.

Ferdinand also laid down that every instrument had to be marked with the Royal insignia to certify its accuracy; the owners of instruments had to re-mark them in the presence of a Royal official after any repairs were carried out.

Many dispositions that Ferdinand laid down are still present in the Italian regulations currently in force, with some modifications made of course.

Lastly, the punishment for offenders who did not observe the law was a fine of 1 000 golden ducats payable to the Crown - an amount so high that breaching the law was effectively discouraged [1].

King Ferdinand I of Aragon set up the basic legal metrology system so well that his directives were left untouched over four centuries until Gioacchino Murat introduced the French decimal metric system in Naples. ■

MEMORIA

SULLA NECESSITA' DI RENDERE UNIFORMI I PESI, E LE MISURE DEL REGNO

D I

D. MELCHIORRE DELFICO

ASSESSOR MILITARE NELLA PROVINCIA DI TERAMO

CUI SI AGGIUNGONO GLI ORDINI, E LE ISTRUZIONI DATE DA FERDINANDO I. DI ARAGONA SULLO STESSO SOGGETTO

NAPOLI MDCCLXXXVII.

Presso Giuseppe Maria Porcelli Libraio, e Stampatore della Reale Acc. Militare.

Con licenza de' Superiori.

Cover page of the book referred to as [1] in the Bibliography

(XXVI)

quod faciatis divulgare per omnes civitates nostras & loca dicte Provincie bannum nostrum puplicum omni qua decet sollemnitate vallatum, quod item vobis mictimus. Et quos inveneritis post equationem dictarum mensurarum & ponderum ac dicti banni divulgationem in totum vel in partem, predictis nostris ordinationibus contravenisse, cogatis & compellatis, ad solvendum penam in bannum ipso adjectam juxta ipsius formam & tenorem: quoniam in premissis & circa premissa vobis concedimus vices, voces, & potestatem nostras, plenarie per presentis mandatis earumdem tenorem universis & singulis Ducibus, Marchionibus, Comitibus, Baronibus, Gubernatoribus, Capitaneis, Syndicis, Universitatibus, & hominibus dicte Provincie, & omnibus aliis ad quos spectabit, & presentes pervenerint, & fuerint quomodolibet presentate: quatenus in predictis vobis pareant, pro quanto gratiam nostram caram habent, & penam mille ducatorum cupiunt evitare, in quorum testimonium presentes fieri fecimus, & parvo nostro sigillo muniri = Datum in Castello novo Neapolis die VI. Aprilis 1480.

REX FERDINANDUS

Cur. XXXVIIII.

Dominus Rex mandavit mihi
ANTONELLO DE PETRUTIIS.

(XXVII)

Istruzioni date per lo Signore Re al magnifico Vincilao de Campitello Thesaurario de Calabria superiore le infrascripte Copie per ipso da eseguirse in le Terre della sua jurisdizione super ponderibus, & mensuris: (ibid. fol. 39. a t.)

IN primis considerando la Majestà del Signore Re li granni dampni & jacture, quali pervenono ad soj subditi & vaxalli, & anco alli negozianti in lo suo Regno per la varietà delli pisi, & misure diverse li quali so in dicto Regno; intendendo ad quilli opportunamente providere ha deliberato, che in tutto quisto suo Regno se habia ad usare da qua în nante lo tomolo, rotolo, marcho, bilance, & canna, le quale se usano in quista Città de Napoli, & per questo ve e stata espedita la commissione super ciò necessaria, & per la espedizione de quella ve facimo le infrascritte istructioni vz.

In primis ve se manda le infrascripte misure vz. thomolo, meczo thomolo, quarto de thomolo, meczo quarto de thomolo, rotolo, decina ciò è quarto de rotolo, meczo rotolo uno terczo de rotolo, uno quarto de rotolo, marcho, e bilance, canna mecza canna, & ulterius ve se manda lo marcho, con lo quale debeate merchare, & fare merchare le misure supradicte, & volimmo, che essendono vui in le Terre de vostra jurisdictione farrite dare ad ciascuna de dicte Terre un thomolo aiustato, & merchato, uno meczo thomolo similiter, uno quarto de thomolo, & uno meczo quarto de thomolo similiter

D 2 aiu-

The Latin text of King Ferdinand's Weights and Measures Act dated 4th April 1480, as reported by Melchiorre Delfico

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[4] De Ritis: "Il nostro sistema metrico sanzionato con la Legge del di 6 di aprile 1840" (from the 1841 Annals)

[5] Afan de Riveira: "Sulla restituzione del nostro sistema di misure, pesi e monete alla sua antica perfezione" (Naples, 1838)

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[8] Col. V. Ferdinando: "Del sistema metrico uniforme che meglio si conviene ai domini al di qua del Faro del Regno delle due Sicilie" (Naples, 1832)

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meetings OIML réunions

International Working Group: OIML TC 3 *Metrological Control*

Maison de la Chimie, Paris, 1–3 June 1999

Secretariat: United States of America

Chairman: Sam Chappell

Participation: Forty delegates representing nineteen OIML Member States, one Corresponding Member, the OIML Development Council, one liaison organization and the BIML, as detailed below

P-members: Australia, Belgium, Bulgaria, P.R. of China, Czech Republic, Denmark, France, Germany, Japan, Netherlands, Norway, Poland, Russia, Sweden, United Kingdom, USA

O-members: Finland, Slovakia, Switzerland

OIML Corresponding Member: Albania

Liaison institution: CECIP

OIML Development Council: Tunisia

Objective:

To discuss the fourth draft OIML Document *Mutual Acceptance Agreement on OIML Pattern Evaluation* and to provide a status report on the work of OIML TC 3 *Metrological Control*

Discussion topics reported on:

1 **TC 3/SC 5 *Conformity Assessment***

2 **Fourth Draft OIML Document *Mutual Acceptance Agreement on OIML Pattern Evaluation***

3 **Expression of Uncertainty in Measurement**

4 **Reports on the Status of Work**

5 **Resolutions of the Meeting**

Forty delegates attended the OIML TC 3 meeting in Paris, chaired by Sam Chappell (CIML Vice-President)

1 TC 3/SC 5 *Conformity Assessment*

Prior to the meeting, the Secretariat distributed a ballot to P-members for comment and vote on the establishment of a new subcommittee TC 3/SC 5 *Conformity Assessment*, whose objective would be to establish rules and procedures for fostering mutual confidence in the results of testing measuring instruments under legal metrology control among OIML Member States. The USA and the BIML were proposed to hold the joint Secretariat for TC 3/SC 5.

The results of the ballot were as follows: 22 out of the 24 ballots were returned (missing: Austria and France) with 20 "Yes" votes and 2 abstentions (Germany and Norway). Written comments on the ballot were received from Australia, Germany and the United Kingdom. Of those who responded, 18 Member States registered to become P-members and 7 as O-members. It was declared that TC 3/SC 5 could be established subject to CIML approval.

During the meeting, the following projects were identified as to be maintained:

- Document on the *OIML Certificate System for Measuring Instruments*;
- Draft Document on *Mutual Acceptance Agreement on OIML Pattern Evaluation*; and
- Working Draft Document on the *Expression of Uncertainty in Measurement in Legal Metrology Applications*.

2 Fourth Draft OIML Document *Mutual Acceptance Agreement on OIML Pattern Evaluation*

The fourth draft Document was reviewed clause by clause and the following principal changes were agreed upon:

- the requirements for participation should be clearly expressed in the Scope and elsewhere where appropriate;
- provision should be made for OIML Member States to indicate that they would accept certificates of conformance issued under the Agreement;
- both the evaluation body and the certification body should be assessed for competence;
- accreditation or peer review could be used to assess competence for the purpose of establishing mutual confidence;
- requirements for establishing competence should be equivalent for either process;
- assessment teams should be made up of experts for testing the category of instruments addressed and at least one quality systems expert; and
- the *Questionnaire on National Capabilities*, Annex C in the Draft Document, should be made generic.

It was agreed that supplementary Documents needed to be developed for assessing the competence of participants. Such Documents should be based on existing or draft ISO/IEC Guides and Standards in which the relevant legal metrology applications would be addressed. The following were identified:

- ISO DIS 17025 *General Requirements for the Competence of Testing and Calibration Laboratories*. G. Lagauterie provided a complementary text for interpreting the requirements as applied to pattern evaluation in legal metrology;
- ISO/IEC Guide 65 *General Requirements for Bodies Operating Product Certification Systems*. John Birch, assisted by the secretariat, will investigate the status of this Guide and recommend how an interpretation document should be developed as applied to certifying bodies issuing certificates under the agreement; and
- ISO/IEC Guide 68 *Considerations on Entering into Mutual Recognition Agreements* and EA-2/02 *EA Policy and Procedures for the Multilateral Agreement* (November 1998). G. Engler agreed to seek permission from his management to develop criteria for assessment teams that would evaluate participants in the Agreement.

3 Expression of Uncertainty in Measurement

A second Working Draft Document on the *Guide for Considering Measurement Uncertainty in Legal Metrology* by G. Lagauterie had been distributed together with comments by the USA prior to the meeting. The topic of uncertainty was discussed in presentations as follows:

- K. D. Sommer gave a presentation on *Uncertainty in Measurement* in which he addressed the approach for expressing uncertainty separately for "calibrated" and "verified" measuring instruments (see **technique**);
- S. Chappell gave a presentation on "Traceability in Measurement" and its importance in establishing confidence in measurement at international level and its influence on the definition of uncertainty for legal metrology applications; and
- G. Lagauterie presented a paper with examples for fluid measuring instruments to supplement the approach taken in the working draft. The title of the paper was *Origins of measurement uncertainties when calibrating or verifying a measuring instrument*.

It was agreed to continue the work in developing an OIML Document on the *Expression of Measurement Uncertainty in Legal Metrology Applications*. A task group with representatives from France, Germany and the USA was identified to continue the effort. Others having an interest were invited to participate and should identify themselves.

4 Reports on the Status of Work

Written reports were provided by the Secretariats on the status of the work of the following subcommittees:

- TC 3/SC 1 *Pattern Approval and Verification* (USA);
- TC 3/SC 2 *Metrological Supervision* (Czech Republic);
- TC 3/SC 3 *Reference Materials* (Russian Federation); and
- TC 3/SC 4 *Statistical Methods* (Germany)*.

Time did not permit a discussion of these reports, but copies may be obtained from the BIML on request.

5 Resolutions of the Meeting

1. According to the response to the ballot of P-members, TC 3/SC 5 *Conformity Assessment* was approved by TC 3 to be established with the co-Secretariat of the USA and the BIML.
2. The minutes of the meeting to record the major points of the discussions will be prepared by the Secretariat and distributed to all participants within one month.
3. Written comments by participants on the 4th draft OIML Document *Mutual Acceptance Agreement on OIML Pattern Evaluation* should be submitted to the Secretariat by no later than July 15, 1999.
4. On the basis of the discussions held at the meeting and the written comments received, the Secretariat will prepare a 5th draft OIML Document for distribution to collaborators in the work of OIML TC 3/SC 5 by August 15, 1999.
5. At its October meeting, the CIML will be provided with a report on the proposal to establish OIML TC 3/SC 5 and its objectives, scope and work program. The CIML will be requested to endorse the work.
6. An interpretation Document shall be developed by a task group on the application of the ISO DIS 17025 to laboratories performing "pattern approval tests" in legal metrology. Comments on the initial draft on this subject should be submitted to Mr. Lagauterie and the Secretariat by no later than July 15, 1999.
7. An interpretation Document shall be developed by a task group on the application of the ISO/IEC Guide 65: 1996 *General Requirements of Bodies Operating Quality Product Certification Systems* to national responsible bodies performing pattern evaluation and/or issuing "certificates of pattern approval" in legal metrology.
8. A task group consisting of representatives from France, Germany and the USA was requested to develop a new draft on the "expression of uncertainty" as applicable in legal metrology based on the discussions held at the meeting. ■

Sam Chappell

* Since TC 3/SC 4 is to restart its activities under the responsibility of Germany, a full report is printed overleaf

Status Report: TC 3/SC 4 *Application of statistical methods for measuring instruments*

1 Preliminary remarks

At the 33rd CIML Meeting in Seoul Prof. Kochsiek agreed that Germany should take on the chairmanship of TC 3/SC 4 *Application of statistical methods*.

Statistical control methods in legal metrology are urgently needed (and indeed already widely discussed) in connection with a number of International Recommendations; below are some suggestions as to how this subject could be dealt with in the future.

2 Statistical control methods in legal metrology

Statistical sampling methods are a compromise between the (reduced) accuracy of an estimation and the whole entity of a test as would be necessary for a complete or individual test. Statistical control methods may also be considered as quality assurance measures taken in differing cases, i.e.:

- preventive assessment with a view to future use;
- follow-up assessment on whether the given characteristics were actually met.

A different case is the assessment of measuring devices already in use, for example electricity meters. In this case it is possible to examine by sampling inspection whether, after several years of operation, the electricity meters still give measurement results which are so good that the meters may remain part of the electricity supply system for a further time period. In its modified form the sampling plan may provide information about the state of a measuring instrument batch already in use.

As there are a large number of differing applications of statistical methods, a uniform control level should not be assumed. Experience gained from a large variety of measuring instruments has shown that it is more expedient to define individual problems with their own statistical conditions.

For example, where measuring instruments are manufactured in highly automated processes significant statements on measurement parameters may already be made on the basis of internal quality checks. However, where they are manufactured in manual processes other marginal conditions apply which will also have to be taken into consideration by the statistical control methods.

3 Level of protection (essential for the sampling plan)

Similar to a modern production line that is managed using a quality system, quality objectives also have to be initially defined in the legal metrology field.

The concept of a sampling plan aimed at either acceptance or rejection will always be oriented to such quality objectives, i.e. the level of requirements. For example, where measuring instruments subject to legal control do not meet the relevant requirements, economic disadvantages for the supplier or the consumer, health risks or safety problems may arise.

These shortcomings have to be weighted according to their significance and are to be taken into consideration in the testing procedure. Wherever the highest level is to be achieved the individual control of each measuring instrument with the corresponding workload involved will be necessary. However, in many cases it will be expedient to specify the control level in accordance with the application of the unit under test in order to optimize the cost-benefit ratio - meaning to adapt the scope of control to the metrological needs. Hence, statistical tests at a statistically calculated protection level will generally be possible and will make sense. On the other hand this will mean that the measuring instrument manufacturer will have to orientate his quality system to the protection level required by legal metrology.

4 Fundamental assessment situations

Statistical tests at a corresponding protection level are conceivable as follows:

- A batch of new measuring instruments is to be used for the first time in the legal sphere.

  Statistical assessment considers the new state of the instruments, which have to comply with a given pattern and which are assessed according to the characteristics of the pattern. The sampling plan will take into account which batch qualities will imply definite acceptance and which will imply definite rejection. The acceptance and rejection characteristics have to be clearly and basically defined; rejection of the batch will (in the worst case) lead to a marketing prohibition which may, however, be repealed if the instruments are repaired.

- A batch of instruments has been in use for a longer period of time. Within the framework of a market surveillance it is to be assessed whether the batch does in fact fulfil the requirements to be met for the application, or the batch condition is to be analyzed.

  In such a case it will be necessary to apply a satisfactory separation method on the basis of an appropriate sampling plan to achieve an effective separation of good and bad batches. Due to the fact that the instruments are already in use, the whole sampling procedure becomes more complicated since the application conditions as well as the operational influences will be taken into account by the procedure.

- If it becomes obvious during such a procedure that the batch does not meet the legal requirements, this might have the consequence that the batch may no longer be used. By further analysis such statistical controls may provide suitable results on the duration period of a batch in use and on a sensible scope of error limits.

- On the basis of a sample it is to be checked whether legal requirements are met or not. In the latter case the result will lead to measures such as warnings or fines being imposed on the responsible person, for which the assumption of an offence has to be reliable (statistical reliability e.g. ≥ 95 %).

A test result produced on the basis of statistics can result in legal action being taken only after it has been corrected by the statistical uncertainty. Besides, the rejection of such a batch may lead to a marketing or use prohibition.

5 Possible action to be taken in TC 3/SC 4

It has to be assumed that the various OIML Member States have differing ideas on the effect of sampling procedures. Here, even further-reaching methods than those mentioned above are conceivable.

Therefore it has to be one of the predominant tasks in determining the scope of TC 3/SC 4 to define the subject in such a way that the participating countries' ideas on the system will be taken into consideration. In this connection the definition of the framework conditions to be taken into account in the drawing up of such plans is more important than the establishment of specific sampling plans. Here, guidelines for the protection level to be considered for the various fields in legal metrology have to be particularly mentioned. Questions to be asked in this context are:

- Which percentage of a batch to be used may exceed the maximum permissible errors (mpe) on verification or in service respectively, and which percentage may be tolerated or not in case of component failures?
- Which percentage of a batch may exceed the mpe on testing at the end of an application period?
- What statistical reliability (99.5 %, 99 %, 95 %) has to be prescribed for which measuring instruments and for which applications?
- What rejection rate may not be exceeded by the manufacturer of certain measuring instruments within the framework of his quality assurance measures?

If such requirements are satisfactorily defined, principles for the establishment of sampling plans may be derived. Undoubtedly, individual testing plans will have to be developed for individual categories of measuring instruments which should, however, be oriented towards the fundamental guidelines.

6 Further action

Once TC 3/SC 4 has elaborated the principles for statistical control methods, the testing plans appropriate for the relevant categories of measuring instruments and their intended use should be further developed within the same subcommittee.

In fact, TC 12 is currently revising OIML R 46 on electricity meters. However, the statistical control plans elaborated here will also apply to the other line-bound household meters (water, heat, gas), since with the same protection level the same mathematical principles (and formulae) will be applicable. Some experience was already gained in this matter at international level so that TC 3/SC 4 might elaborate the general guidelines and prepare the control plans specific for the use of utility meters.

TC 6 is dealing with prepackages, i.e. the revision of R 87 *Net content in packages*. TC 6 might be the appropriate body to elaborate the statistical methods for the control of net filling quantities, so this will not be a subject to be dealt with under TC 3/SC 4. However, Germany is prepared to cooperate with TC 6.

In order to be able to start work this year, a questionnaire was distributed to CIML Members to ascertain which Member States are willing to participate in TC 3/SC 4 as permanent, active members or observers. ■

liaison activities OIML activités de liaison

CECIP: 49ème Assemblée Générale

Budapest (Hongrie), 14 mai 1999

Le CECIP, *Comité Européen des Constructeurs d'Instruments de Pesage*, vient de tenir sa 49ème Assemblée Générale à Budapest en Hongrie, à l'invitation de la Fédération Hongroise, MATE, *Méréstechnikai és Automatizálási Tudományos Egyesület*.

Ce grand événement annuel pour les industriels du pesage, permet aux treize Fédérations adhérentes à ce jour, de se retrouver, de faire le bilan de l'année écoulée, et de préparer l'avenir. Ces Fédérations représentent les pays suivants:

Allemagne, Belgique, Espagne, Finlande, France, Hongrie, Italie, Pays Bas, Pologne, Royaume-Uni, République Slovaque, Suisse et République Tchèque.

Ce rendez-vous se perpétue depuis le 29 mai 1959, date de création du CECIP avec cinq Fédérations: Allemagne, Belgique, France, Italie et les Pays-Bas, qui suivaient le chemin ouvert par le Traité de Rome en 1957.

L'Assemblée Générale est l'occasion d'inviter des experts ou des personnalités d'organismes internationaux ou européens pour nous faire part de leur politique ou de leur point de vue sur des sujets touchant le pesage. Cette année nous avions l'honneur de recevoir:

- Madame Lászlóné Kovács, Chef de Département du Groupe de Conseillers du Gouvernement au Ministère des Affaires Economiques Hongrois avec un discours sur la stratégie économique à moyen terme du Gouvernement Hongrois;
- Le Dr. Péter Bölöni, Président de la Section Métrologique de la MATE et Directeur Scientifique et de l'Éducation de SZENSOR Métrologie, qui a présenté la qualification des instruments de mesure sur la base de la nouvelle approche sur l'incertitude des mesures;
- Madame Mairead Buckley, de la Commission Européenne, DG III, Industrie, qui nous a parlé du projet de directive sur les instruments de mesure.

Toutes ces interventions de grande qualité ont été très appréciées par l'ensemble des délégués.

Puis chaque Fédération a présenté la situation de l'industrie du pesage dans son pays, avec un tableau récapitulatif joint de la production d'instruments de pesage en Europe.

La partie statutaire comprenait entre autres les rapports d'activité de chaque groupe de travail et l'élection d'un nouveau Vice-Président, M. Dick Farman.

Nous avons eu le plaisir d'accueillir, pour la première fois, une délégation de la Fédération de l'Ukraine, venue en tant qu'invitée avec une admission possible, en tant que membre du CECIP, en 2000.

Nous amis Hongrois avait parfaitement organisé cette Assemblée Générale, qui fut clôturée par un dîner de gala dans le cadre d'un superbe restaurant sur les hauteurs de Budapest, puis par une excursion le long du Danube à la découverte des merveilleuses villes d'Esztergom, de Visegrad et de Szentendre. ■

Michel TURPAIN,
Secrétaire Permanent

CECIP: 49th General Assembly

Budapest (Hungary), 14 May 1999

CECIP, the *European Committee of Weighing Instrument Manufacturers*, held its 49th General Assembly in Budapest, Hungary, at the invitation of the Hungarian Federation, MATE, *Méréstechnikai és Automatizálási Tudományos Egyesület*.

During this key annual meeting of weighing industry members the thirteen member Federations met to evaluate the past year's activities and prepare the future strategy. These Federations represent the following countries:

Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Spain, Netherlands, Poland, Slovak Republic, Switzerland and the United Kingdom.

This meeting has been an annual event since 29 May 1959, the date on which CECIP was formed with five member Federations: Belgium, France, Germany, Italy, Netherlands, following the 1957 Treaty of Rome.

The General Assembly is an opportunity to invite experts and key individuals from international or European bodies to report on their policies and to share their views on weighing related subjects. This year the Assembly was honored to welcome:

- Mrs. Lászlóné Kovács, Head of Department of the Governmental Advisory Group in the Hungarian Ministry for Economic Affairs, who gave a speech on the Hungarian Government's medium-term economic strategy;
- Dr. Péter Bölöni, Chairman of the Metrology Section of MATE and Scientific and Educational Director of SZENSOR Metrology, who gave a presentation on qualifying measuring instruments based on the new approach to uncertainty in measurement;
- Mrs. Mairead Buckley of the European Commission, DG III, Industry, who talked about the draft Measuring Instruments Directive.

All these presentations were of a high standard and were much appreciated by delegates.

Each Federation then presented the situation of the weighing industry in its country, including a combined table summarizing weighing instrument production in Europe.

In addition, the regular agenda items included activity reports by each working group and the election of a new Vice-President, Mr. Dick Farman.

It was a pleasure to welcome, for the first time, the delegation from the Federation of Ukraine, who were attending as guests and who envisage perhaps joining CECIP as members in the year 2000.

CECIP's Hungarian hosts made a perfect job of organizing this General Assembly, which ended with a gala dinner in a superb restaurant in the upper part of Budapest, followed by an excursion along the Danube to discover the marvellous towns of Esztergom, Visegrad and Szentendre. ■

Michel TURPAIN,
Permanent Secretary

Statistiques, Industrie du Pesage (1998) — **Weighing Industry Statistics, 1998**

Pays *Country*	Production HT Monnaie locale *Ex VAT local currency*	Production M. Euro	Variation /1997	Export Variation/1997	Import Variation/1997
Allemagne *Germany*	1 344 M. DM	687,2	+ 2 %	671 M. DM – 2 %	336 M. DM – 3 %
Belgique *Belgium*					
Espagne *Spain*	20 086 M. PTS	120,7	+ 7,1 %	4 127 M. PTS + 8 %	5 280 M. PTS + 30,2 %
Finlande *Finland*	140 M. FIM	23,5	+ 3,7 %	30,6 M. FIM – 10 %	80,2 M. FIM + 23,4 %
France *France*	1 187 M. FF	181	+ 6,9 %	456 M. FF + 12 %	723 M. FF + 12,4 %
Hongrie *Hungary*					
Italie *Italy*	160 394 M. ItL	82,8	+ 4,1 %	36 270 M. ItL + 3,6 %	37 270 M. ItL + 0,35 %
Pays Bas *Netherlands*					
Pologne *Poland*					
Rép. Tchèque *Czech Republic*	346 M. Kc	9,2	– 8,9 %	26 M. Kc – 7,2 %	99 M. Kc – 19,8 %
Royaume-Uni *United Kingdom*	120 M. £	182,5	0 %	89,58 M. £ – 9,14 %	83,5 M. £ + 8,16 %
Suisse *Switzerland*				M. FS + 2,6 %	M. FS + 9,1 %

WTO Symposium on Conformity Assessment Procedures

(Geneva, 8–9 June 1999)

Following the First Triennial Review of the Agreement on Technical Barriers to Trade (TBT) the WTO TBT Committee decided at its meeting on 31 March 1999 to organize a Symposium on Conformity Assessment Procedures to deepen its understanding of a number of different issues including:

- relevant international guides and recommendations for conformity assessment;
- the types of conformity assessment procedures (CAPs) and the conditions for their application;
- the various approaches for the recognition of the results of CAPs; and
- the role of international and regional systems for conformity assessment.

Each of these themes was taken up in a separate session with Main Speakers and Panelists followed by Panel Discussions.

The Symposium was held in the new conference hall of the WTO headquarters with over 150 participants, including 36 speakers (with 41 lectures) who represented 8 international organizations (BIPM, IAF, IEC, ILAC, ISO, OECD, OIML and WTO), 6 regional organizations (APLAC, EA, EC, IAAC, PAC and SADCA) and over 20 national institutions and private companies.

Introductory Session

The Symposium began with a brief presentation of the main provisions of the Agreement on CAPs followed by presentations by a number of speakers on the CAPs that are used for business transactions in the market place. It was recognized that CAPs should not create unnecessary obstacles to trade; at the same time it was noted that effective harmonized CAPs are a necessary mechanism to establish confidence between different players in the market place.

Session I

Relevant International Guides and Recommendations for Conformity Assessment

This session focused on ISO/IEC Guides, on Committee Members' experience in the use of relevant international guides, and the extent to which those guides and recommendations have served as a basis for the implementation of CAPs by bodies in their territories, and have helped to ensure a harmonized approach to conformity assessment. These guides are widely used both by developed and developing countries. It was noted that it is important to develop guides reasonably quickly so as to meet the needs of the market place. It was also noted that while different conformity assessment players could in theory use the same international standards, variations in interpretation (based on language and geographical differences for example) could lead to different applications. It was suggested that international trade could stand to benefit from CAPs, which are transparent, impartial and based on international standards.

Among the main speakers the Chairman of the ISO Committee on Conformity Assessment introduced the activity of ISO/CASCO and mentioned that among other elements CASCO would focus on:

- revising and reissuing publications/Guides as standards;
- developing a comprehensive system of documented guidance; and
- taking users' experience into consideration in priority setting and content revision.

The BIML representative introduced those OIML activities that are of relevance to the issues dealt with in the four Symposium Sessions:

- the development of OIML Recommendations - as international standards - that specify harmonized metrological performance requirements of the measuring instruments concerned and detailed conformity assessment procedures to harmonize the tests to which measuring instruments are submitted;

- the operation of the OIML Certificate System, which facilitates trade of measuring instruments;
- the recent establishment of a new OIML technical body to develop a Mutual Acceptance Agreement on OIML pattern evaluations and two interpretation documents on applying ISO DIS 17025 and ISO/IEC Guide 65 for assessment of pattern evaluation test laboratories and legal metrology certification bodies respectively;
- the development of an OIML International Document on *Initial verification of measuring instruments utilizing the manufacturer's quality system*; and
- projects envisaged which take into account the needs of developing countries.

Panelists - among others the Chairpersons of ILAC and IAF - reported on the experience of their respective organizations on the use of the relevant International Guides/Recommendations as practitioners.

Session II

Various Types of Conformity Assessment Procedures and their Conditions of Application

It was noted that third party evaluation of conformity is widely used, supported in many cases by national accreditation systems as a tool for demonstrating the technical competence of conformity assessment bodies. It is used for the assessment of conformity to both voluntary standards (for products and quality systems) and to mandatory regulations. A number of issues were raised, e.g. the need for harmonized and consistent accreditation procedures, and a code of good practice for conformity assessment bodies.

It was indicated that some regulators accept supplier declarations of conformity in certain sectors. In some instances these declarations have to be underpinned by test results obtained from an accredited conformity assessment body. It was recognized that while supplier declaration is appropriate some cases, it is not appropriate in areas of great risk, and that it has to be accompanied by appropriate legislation, for example on liability, and effective post-market surveillance. In this respect, concerns were raised regarding the responsibility for products originating from abroad.

The European Commission representative, speaking of third party evaluation of conformity and accreditation, stressed that the main goal of the EC's regulatory system is to achieve confidence among all actors in the market place.

A speaker from the USA presented a national experience on supplier declaration of conformity mentioning that a number of US regulatory agencies also relied on this method, which saved costs, associated with assuring conformance.

Session III

Approaches with Respect to the Recognition of Conformity Assessment Procedure Results

It was noted that numerous mutual recognition agreements (MRAs) had been concluded, and that several different types of MRAs existed, e.g. between regulatory bodies (i.e. government to government) and non-regulatory bodies (i.e. private sector). It was recognized that the cost-effectiveness of MRAs was an issue that needed to be assessed carefully. Costs tend to be extremely high when conformity assessment systems are different in participating countries. While the numerous benefits from MRAs were stressed, it was explained by several speakers that MRAs are not the only option to address recognition issues, and may not be the appropriate option in a number of cases. It was also noted that they could not remedy serious market access problems.

Some concerns were expressed with respect to the discriminatory effects on trade of some governmental MRAs.

MRAs in the non-regulatory sector were also discussed and it was stated that the principle of national treatment for third party conformity assessment bodies from other countries/regions could enable those parties to participate in conformity assessment activities under conditions not less favorable than domestic bodies. MRAs in the non-regulatory sector could create a global network of organizations which are authorized to conduct conformity assessment for different requirements imposed by a variety of markets and facilitate quick market access.

In addition to MRAs, attention was drawn to the autonomous recognition of conformity as a tool for the recognition of conformity assessment results and which is in accordance with the TBT Agreement. Although reciprocity should not be set as a precondition for autonomous recognition, the establishment of confidence is essential. While participation by relevant conformity assessment bodies in international and regional systems could facilitate this process, other means such as peer evaluation could also be employed.

The European Commission representative spoke of different kinds or levels of mutual recognition agreements and their cost effectiveness comparing costs and benefits, and the Swiss representative presented positive national experience in the recognition of the results of foreign conformity assessment (autonomous recognition).

Session IV

The Role of International and Regional Systems for Conformity Assessment

A number of international organizations (such as BIPM, ILAC, IAF and IEC) and regional bodies (such as APLAC, EA, IAAC and SADC) introduced their systems and activity in the field of conformity assessment.

It was recognized that:

- international guides are commonly used by these systems;
- these systems play a useful role in coordinating the conformity assessment bodies;
- through these systems technical assistance could be provided and technical know-how could be transferred to developing countries;
- regional systems could be formed/tailored to address the particular situation of different regions; and
- there is a need to avoid the duplication of work among different systems at all levels.

The BIPM representative gave an overview on the existing international and regional systems for conformity assessment in metrology (including the OIML Certificate System), introduced the activities of the BIPM and noted that after several years' preparatory work a Mutual Recognition Agreement on measurement standards and calibrations was expected to be signed on the occasion of the 21st *Conférence Générale des Poids et Mesures* (CGPM) to be held in Paris in October 1999.

The ILAC representative gave a presentation on MRAs in the international laboratory community and ILAC's role in these arrangements. She explained ILAC's objectives to foster confidence between member bodies and to assist countries in developing laboratory accreditation systems, which is fundamental in supporting trade. She observed the trend that bilateral MRAs were moving to regional ones, which were easier to operate and explained that ILAC could play a useful role to enable new regions and unaffiliated laboratories to integrate into the system, coordinate regional accreditation programs and provide a global network in the long term. ILAC has already established liaisons with ISO, IEC, IAF, BIPM, OIML and WTO and regional laboratory accreditation systems in the Asia-Pacific, Europe, South and North America. ■

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OIML certificate system / système de certificats

In this Bulletin: OIML certificates registered

Dans ce Bulletin: certificats OIML enregistrés

1999.05 – 1999.07

OIML Certificate System

The OIML *Certificate System for Measuring Instruments* was introduced in 1991 to facilitate administrative procedures and lower costs associated with the international trade of measuring instruments subject to legal requirements.

The System provides the possibility for a manufacturer to obtain an OIML certificate and a test report indicating that a given instrument pattern complies with the requirements of relevant OIML International Recommendations.

Certificates are delivered by OIML Member States that have established one or several Issuing Authorities responsible for processing applications by manufacturers wishing to have their instrument patterns certified.

OIML certificates are accepted by national metrology services on a voluntary basis, and as the climate for mutual confidence and recognition of test results develops between OIML Members, the OIML Certificate System serves to simplify the pattern approval process for manufacturers and metrology authorities by eliminating costly duplication of application and test procedures. ■

Système de Certificats OIML

Le *Système de Certificats OIML pour les Instruments de Mesure* a été introduit en 1991 afin de faciliter les procédures administratives et d'abaisser les coûts liés au commerce international des instruments de mesure soumis aux exigences légales.

Le Système permet à un constructeur d'obtenir un certificat OIML et un rapport d'essai indiquant qu'un modèle d'instrument satisfait aux exigences des Recommandations OIML applicables.

Les certificats sont délivrés par les États Membres de l'OIML, qui ont établi une ou plusieurs autorités de délivrance responsables du traitement des demandes présentées par des constructeurs souhaitant voir certifier leurs modèles d'instruments.

Les services nationaux de métrologie légale peuvent accepter les certificats sur une base volontaire; avec le développement entre Membres OIML d'un climat de confiance mutuelle et de reconnaissance des résultats d'essais, le Système simplifie les processus d'approbation de modèle pour les constructeurs et les autorités métrologiques par l'élimination des répétitions coûteuses dans les procédures de demande et d'essai. ■

This list is classified by Issuing Authority; updated information on these Authorities may be obtained from the BIML.

Cette liste est classée par Autorité de délivrance; les informations à jour relatives à ces Autorités sont disponibles auprès du BIML.

► Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R51/1996 - DE - 98.03

Type GS ... (Classes X(1) and Y(a))

Bizerba GmbH & Co. KG, Wilhelm-Kraut-Straße 65, D-72336 Balingen, Germany

For each Member State, certificates are numbered in the order of their issue (renumbered annually).

Pour chaque État Membre, les certificats sont numérotés par ordre de délivrance (cette numérotation est annuelle).

OIML Recommendation applicable within the System / Year of publication

Recommandation OIML applicable dans le cadre du Système / Année d'édition

Year of issue

Année de délivrance

The code (ISO) of the Member State in which the certificate was issued.

Le code (ISO) indicatif de l'État Membre ayant délivré le certificat.

Certified pattern(s)

Modèle(s) certifié(s)

Applicant

Demandeur

For up to date information on OIML certificates:

Pour des informations à jour sur les certificats OIML:

http://www.oiml.org

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Continuous totalizing automatic weighing instruments (belt weighers)
Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande)

R 50 (1997)

Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R50/1997-GB-99.01
Continuous totalizing automatic weighing instrument (belt weigher), model Resometric MCS 9600 (Class 1)
Inflo Control Systems, a Division of Procon Engineering Ltd., Vestry Estate, Otford Road, Sevenoaks, Kent TN14 5EL, UK

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic catchweighing instruments
Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique

R 51 (1996)

Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R51/1996-DE-99.04
Automatic catchweighing instrument in shovel dozers, type MASTER 196 (Class Y(b))
3B6 Sistemi Elettronici Industriali s.r.l., Via Sivo, 74, 28053 Castelletto Ticino (NO), Italy

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Load cells
Cellules de pesée

R 60 (1991), Annex A (1993)

Issuing Authority / *Autorité de délivrance*

Danish Agency for Development of Trade and Industry, Division of Metrology, Denmark

R60/1991-DK-99.01
Double-ended load cell type DB-50000S (Class C)
Cardinal Scale Manufacturing Co., 203 East Daugherty St., Webb City, Missouri 64870, USA

Issuing Authority / *Autorité de délivrance*

Centro Español de Metrologia, Spain

R60/1991-ES-99.01
Type TCC-1 (Class C)
Transdutec S.A., C/ Joan Miró 11, 08930 - Sant Adrià de Besós, Barcelona, Spain

R60/1991-ES-99.02
Type TPF1-6D (Class C)
Transdutec S.A., C/ Joan Miró 11, 08930 - Sant Adrià de Besós, Barcelona, Spain

Issuing Authority / *Autorité de délivrance*

Sous-direction de la Métrologie, France

R60/1991-FR-99.01
*Cellules de pesée à jauges de contrainte ATEX type ACH * C3 SH 5e (Class C)*
Société Precia Molen, BP 106, 07001 Privas cedex, France

Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R60/1991-GB-99.06
Load Cell Type 3100P (Class C1.5)
Sensy S.A., ZI Jermet, Allée centrale, B-6040 Jumet, Belgium

R60/1991-GB-99.07
Beam (bending) load cell model WBLW (Class C)
Salter Weigh-Tronix Ltd., George Street, West Bromwich, West Midlands B70 6AD, United Kingdom

R60/1991-GB-99.08
Load Cell Model 23 DL 12 (Class C3)
P.M. On Board Ltd., Cutler House, Wakefield Road, Bradford BD4 7LU, United Kingdom

Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R60/1991-NL-99.12
Type 220 / 230 (Class C)
Tedea Huntleigh Europe Ltd., 37 Portmanmoor Road, Cardiff CF2 2HB, United Kingdom

Issuing Authority / *Autorité de délivrance*

Bureau Roumain de Métrologie Légale, Romania

R60/1991-RO-99.01
Type SC (Class C)
Esit Elektronik Sistemler Imalat ve Ticaret Ltd. STI, Mühürdar Cad. 91 Kadiköy, TR-81300 Istanbul, Turkey

Issuing Authority / *Autorité de délivrance*

National Institute of Standards and Technology, United States of America

R60/1991-US-99.02 Rev. 1
Load Cell Model 9363 (Class C)
Revere Transducers, Incorporated, 14192 Franklin Avenue, Tustin, California 92680, USA

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic gravimetric filling instruments
Doseuses pondérales à fonctionnement automatique

R 61 (1996)

Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R61/1996-DE-98.01 Rev. 1
Dialog 165 accuracy class Ref (0.2)
Weber-Waagenbau u. Wägeelektronik GmbH, Boschstraße 7, 68753 Waghäusel 1, Germany

R61/1996-DE-99.01
Type MEC II-20 accuracy class Ref (0.2)
Haver & Boecker, Carl-Haver-Platz, 59302 Oelde, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Nonautomatic weighing instruments
Instruments de pesage à fonctionnement non automatique

R 76-1 (1992), R 76-2 (1993)

Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R76/1992-DE-99.06
Type CS 300... (Class III)
Bizerba GmbH & Co. KG, Wilhelm-Kraut-Straße 65, D-72336 Balingen, Germany

Issuing Authority / *Autorité de délivrance*

Danish Agency for Development of Trade and Industry, Division of Metrology, Denmark

R76/1992-DK-99.01
Type 778 (Class III)
Cardinal Scale Manufacturing Co., 203 East Daugherty St., Webb City, Missouri 64870, USA

R76/1992-DK-99.02
Type 758 (Class III)
Cardinal Scale Manufacturing Co., 203 East Daugherty St., Webb City, Missouri 64870, USA

R76/1992-DK-99.03
Type 708 (Class III)
Cardinal Scale Manufacturing Co., 203 East Daugherty St., Webb City, Missouri 64870, USA

R76/1992-DK-99.04
Type 748 (Class III)
Cardinal Scale Manufacturing Co., 203 East Daugherty St., Webb City, Missouri 64870, USA

▶ Issuing Authority / *Autorité de délivrance*

Centro Español de Metrologia, Spain

R76/1992-ES-98.01
Nonautomatic, graduated, self-indicating, electronic counter-top weighing instrument, type "BASIC" intended for direct sale to the public (Class III)

Campesa S.A., Avinguda Cova Solera, 25-29, E-08191 Rubi-Barcelona, Spain

R76/1992-ES-99.01
Nonautomatic, graduated, self-indicating, electronic counter-top weighing instrument, type "PLUS-20" intended for direct sale to the public (Class III)

Campesa S.A., Avinguda Cova Solera, 25-29, E-08191 Rubi-Barcelona, Spain

R76/1992-ES-99.02
Nonautomatic, graduated, self-indicating, electronic counter-top weighing instrument, type "BASIC-Autonoma" intended for direct sale to the public (Class III)

Campesa S.A., Avinguda Cova Solera, 25-29, E-08191 Rubi-Barcelona, Spain

R76/1992-ES-99.03
Type BASIC PRINT (Class III)

Campesa S.A., Avinguda Cova Solera, 25-29, E-08191 Rubi-Barcelona, Spain

▶ Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R76/1992-GB-99.03
Defiant SP20 (Class III)

Defiant Weighing Limited, Vestry Estate, Otford Road, Sevenoaks, Kent TN14 5EL, United Kingdom

▶ Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R76/1992-NL-99.04
Type SW ... Series (Class III)

Mettler-Toledo Inc., 1150 Dearborn Drive, Worthington, OH 43085-6712, USA

R76/1992-NL-99.06
Type FX, MC, B, G and BK-series (Class III)

Avery Berkel Weighing, Foundry Lane, Smethwick, Warley, West Midlands B66 2LP, United Kingdom

R76/1992-NL-99.07
Type Viper ..... (Class III)

Mettler-Toledo A.G., Im Langacher, 8606 Greifensee, Switzerland

R76/1992-NL-99.08
SG... Series (Class III)

HAMPEL Electronic Co., Ltd, 2F, No.2, Alley 16, Lane 235, Bao Chiao Rd., Hsintien, Taipei Hsien, Taiwan, R.O.C.

R76/1992-NL-99.09
Type APO30 (Class III)

Hytech Scales Pty Ltd, 15-21 Bellevue Crescent, Preston, Victoria 3072, Australia

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Fuel dispensers for motor vehicles
Distributeurs de carburant pour véhicules à moteur

R 117 (1995) [+ R 118 (1995)]

▶ Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R117/1995-NL-99.02
Fuel dispensers for motor vehicles, model E200 or E600; max. flowrate = 45 l/min (Class 0.5)

Tokheim, Koppens Automatic Fabrieken B.V. Industrieweg 5, 5531 AD Bladel, The Netherlands

R117/1995-NL-99.03
Fuel dispensers for motor vehicles, model E200 or E600; max. flowrate = 80 l/min (Class 0.5)

Tokheim, Koppens Automatic Fabrieken B.V. Industrieweg 5, 5531 AD Bladel, The Netherlands

R117/1995-NL-99.04
Fuel dispensers for motor vehicles, model E200 or E600; max. flowrate = 130 l/min (Class 0.5)

Tokheim, Koppens Automatic Fabrieken B.V. Industrieweg 5, 5531 AD Bladel, The Netherlands

The XVI IMEKO World Congress will be held in Vienna from 25–28 September 2000, organized by ÖGMA (Austrian Society for Measurement and Automation)

Scope of the World Congress

- Education and Training in Measurement and Instrumentation
- Photonic Measurements
- Measurement of Force, Mass and Torque
- Measurement of Electrical Quantities
- Hardness Measurement
- Measurement Science
- Traceability in Metrology
- Flow Measurement
- Technical Diagnostics
- Metrological Infrastructures
- Thermal and Temperature Measurement
- Measurements in Biology and Medicine
- Measurement of Geometrical Quantities
- Experimental Mechanics
- Pressure and Vacuum Measurement
- Measurement in Robotics
- Measurement of Human Functions
- Special Topics for IMEKO-XVI in Vienna
- Micro and Nano Technology
- Estimation of Uncertainty and Errors in Measurement
- Interfaces of Measurement and Decision Making
- Expert Systems in Decision Making
- Statistical Evaluation of Measurement Results
- Quality Management
- Environmental Management
- Sustainable Development and its Indicators

IMEKO

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Web: http://www.imeko2000.at

meetings OIML réunions

November 1999

4–5	TC 8/SC 5 (Water meters)	GAITHERSBURG, USA

October 2000

9–13	11th International Conference of Legal Metrology	LONDON, UK
	35th CIML Meeting	

Committee drafts received by the BIML, 1999.06.01 – 1999.08.31

Title	Language	CD n°	TC/SC	Country
Revision of D 18: General principles of the use of reference materials in measurements	E	1 CD	TC 3/SC 3	Russia
Multi-dimensional measuring instruments - Test report	E	1 CD	TC 7/SC 5	Australia

The OIML is pleased to welcome the following new CIML Members

Japan	**Mr. Sakurai**
Republic of Korea	**Mr. Park**
Slovakia	**Mr. Orlovský**